IDEAS IN CONTEXT

Experimental Philosophy and the Origins of Empiricism

PETER R. ANSTEY AND
ALBERTO VANZO

EXPERIMENTAL PHILOSOPHY AND THE ORIGINS OF EMPIRICISM

The emergence of experimental philosophy was one of the most significant developments in the early modern period. However, it is often overlooked in modern scholarship, despite being associated with leading figures such as Francis Bacon, Robert Boyle, Isaac Newton, Jean Le Rond d'Alembert, David Hume, and Christian Wolff. Ranging from the early Royal Society of London in the seventeenth century to the uptake of experimental philosophy in Paris and Berlin in the eighteenth, this book provides new terms of reference for understanding early modern philosophy and science, and its eventual eclipse in the shadow of post-Kantian notions of empiricism and rationalism. *Experimental Philosophy and the Origins of Empiricism* is an integrated history of early modern experimental philosophy which challenges the rationalism and empiricism historiography that has dominated Anglophone history of philosophy for more than a century.

PETER R. ANSTEY is Professor of Philosophy at the University of Sydney and a Fellow of the Australian Academy of the Humanities. He specialises in early modern philosophy, in particular the philosophy of John Locke, Robert Boyle, Francis Bacon, and the French Philosophes. He is the author of the prize-winning book *John Locke and Natural Philosophy* (2011).

ALBERTO VANZO is an independent scholar. He has been a Marie Curie fellow at the University of Birmingham and the University of Warwick. His research in early modern philosophy ranges from Kant to experimental philosophy.

IDEAS IN CONTEXT

Edited by DAVID ARMITAGE, RICHARD BOURKE and JENNIFER PITTS

The books in this series will discuss the emergence of intellectual traditions and of related new disciplines. The procedures, aims and vocabularies that were generated will be set in the context of the alternatives available within the contemporary frameworks of ideas and institutions. Through detailed studies of the evolution of such traditions, and their modification by different audiences, it is hoped that a new picture will form of the development of ideas in their concrete contexts. By this means, artificial distinctions between the history of philosophy, of the various sciences, of society and politics, and of literature may be seen to dissolve.

A full list of titles in the series can be found at: www.cambridge.org/IdeasContext

EXPERIMENTAL PHILOSOPHY AND THE ORIGINS OF EMPIRICISM

PETER R. ANSTEY
University of Sydney
ALBERTO VANZO
Independent Scholar

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre,
New Delhi – 110025, India

103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781316516461
DOI: 10.1017/9781009030236

© Peter R. Anstey and Alberto Vanzo 2023

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2023

A catalogue record for this publication is available from the British Library.

Library of Congress Cataloging-in-Publication Data
Names: Anstey, Peter R., 1962– author. | Vanzo, Alberto, author.
Title: Experimental philosophy and the origins of empiricism /
Peter R. Anstey, Alberto Vanzo.
Description: Cambridge ; New York, NY : Cambridge University Press, 2023 |
Series: Ideas in context | Includes bibliographical references and index.
Identifiers: LCCN 2022030728 (print) | LCCN 2022030729 (ebook) | ISBN 9781316516461 (hardback) | ISBN 9781009030236 (ebook)
Subjects: LCSH: Philosophy – History | Methodology | Empiricism
Classification: LCC B72 .A57 2023 (print) | LCC B72 (ebook) | DDC 109–dc23/eng/20221006
LC record available at https://lccn.loc.gov/2022030728
LC ebook record available at https://lccn.loc.gov/2022030729

ISBN 978-1-316-51646-1 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

CONTENTS

	List of Figures	*page* vi
	List of Tables	vii
	Acknowledgements	viii
	A Note on Citations	x
	List of Abbreviations	xi
	Introduction	1
	PART I **The Rise of Experimental Philosophy**	17
1	The Origins of the Experimental/Speculative Distinction	19
2	Experimental Philosophy in the Seventeenth Century	43
3	Experimental Natural History	75
	PART II **The Heyday of Experimental Philosophy**	109
4	Mathematical Experimental Philosophy	111
5	Experimental Philosophy in France	149
6	Experimental Natural Philosophy and Moral Philosophy	176
	PART III **From Experimental Philosophy to Empiricism**	201
7	Experimental Philosophy in Eighteenth-Century Germany	203
8	Kant and the Genesis of Empiricism	234
9	Reinhold, Tennemann, and the Rise of Empiricism	258
	Conclusion	285
	Manuscripts Cited	299
	Newspapers, Broadsheets, and Almanacs	300
	References	301
	Index	353

FIGURES

1.1 Experimental philosophy and its relation to the neo-Aristotelian theory of knowledge *page 7*
1.1 Aristotle's division of knowledge 25
1.2 Aquinas' practical/speculative distinction 26
1.3 Toletus' operative/speculative distinction 27
1.4 Sennert's division of philosophy 28
1.5 Francis Bacon's mature division of natural philosophy 35
1.6 Johnston's division of philosophy with natural history 37
4.1 Proposals for an annual course in experimental philosophy at St Salvator's College, University of St Andrews, Scotland, 1700 117
4.2 The final page of Desaguliers' *A Catalogue of the Experiments in Mr Desaguliers's Course*, 1713 118
4.3 James Jurin's weather diary exemplar, *Philosophical Transactions* 32.379, 1723, p. 427 146
6.1 The branches of philosophy in the late seventeenth century 179
6.2 Speculative and practical moral philosophy 180
8.1 A classification of ancient philosophers in Kant's lecture transcripts 244
9.1 One of Reinhold's classifications of the main philosophical movements 267
9.2 Main philosophical movements of the seventeenth and eighteenth centuries according to Tennemann 275
9.3 Seventeenth- and eighteenth-century philosophers discussed for at least forty-five pages in Tennemann's *History of Philosophy*, vols. 10–11 278

TABLES

3.1 Varenius' heads for special geography and Boyle's heads for a natural history of a country *page* 85
4.1 Lecturers in experimental philosophy at the University of Oxford 120
8.1 Early modern philosophers whom Kant explicitly classes as rationalists or empiricists 247
8.2 Early modern philosophers whom Kant appears to regard as rationalists or empiricists 247
9.1 Seventeenth- and eighteenth-century philosophers discussed for at least one section each in Tennemann's *History of Philosophy*, vols. 10–11 276
9.2 Jakob Brucker's classification of seventeenth- and eighteenth-century philosophers 277

ACKNOWLEDGEMENTS

For helpful comments and feedback on the materials on which this book is based, we are grateful to Zvi Biener, Michael Bycroft, Matteo Favaretti Camposampiero, Alan Chalmers, Andrew Cooper, Sorana Corneanu, Greg Dawes, Mihnea Dobre, Mordechai Feingold, Daniel Garber, Stephen Gaukroger, Juan Gómez, Niccolò Guicciardini, Philippe Hamou, Peter Harrison, Helen Hattab, John Henry, Michael Hunter, Dana Jalobeanu, Jamie Kassler, Alex Klein, Dmitri Levitin, Fui Lee Luk, Noel Malcolm, Gideon Manning, Oana Matei, Tim Mehigan, Lucian Petrescu, Tinca Prunea-Bretonnet, Evan Ragland, Sophie Roux, Eric Schliesser, John Schuster, Richard Serjeantson, Stephen Snobelen, Tom Sorell, Hanna Szabelska, Wiep van Bunge, Anik Waldow, Kirsten Walsh, Eric Watkins, Catherine Wilson, Charles Wolfe, John Zammito, and audiences at the Universities of Bucharest, Mainz, Reading, Otago, and Warwick. This work was supported by the Marsden Fund of the Royal Society of New Zealand (grant number UOO0815), the Arts and Humanities Research Council, UK (grant number AH/L014998/1), the Australian Research Council (grant number FT120100282), and a Marie Curie International Incoming Fellowship within the 7th European Community Framework Programme.

We would like to thank the Bodleian Library, Oxford for permission to cite Bodleian MS Bradley 1 and MS Bradley 12; the British Library for permission to cite British Library Add. MS 32545 and British Library Add. MS 32546; Cambridge University Library for permission to cite Cambridge University MS Add. 3968. We would like to thank the National Library of Scotland for permission to reproduce 'Proposals for an annual course of experimental philosophy in St Salvator's College of the University of St Andrews', shelf mark Crawford MB 772 as Figure 4.1. It is reproduced with permission from materials on loan to the National Library of Scotland by the Balcarres Trust. We would also like to thank the National Library of Scotland for permission to reproduce James Jurin's weather diary exemplar, *Philosophical Transactions*, 32.379, 1723, p. 427 as Figure 4.3. We would like to thank the British Library for permission to reproduce the final page of John Theophilus Desaguliers' *A Catalogue of the Experiments in Mr Desaguliers's Course*, 1713, shelf mark C.112.f.9(181) as Figure 4.2. The cover image, 'Two Boys by Candlelight,

Blowing a Bladder', c. 1767–1773, by Joseph Wright of Derby (Object Number 58.16) is used courtesy of the Huntington Art Museum, San Marino, California, USA.

Chapter 1 draws from Anstey and Vanzo, 'The origins of early modern experimental philosophy', *Intellectual History Review*, 22, 2012, pp. 499–518 with permission from Taylor & Francis. Section 2.1 draws from Anstey and Vanzo, 'Early modern experimental philosophy', in *A Companion to Experimental Philosophy*, eds. Justin Sytsma and Wesley Buckwalter, Oxford: Blackwell, 2016, pp. 87–102 with permission from John Wiley and Sons. Section 3.3 draws on Anstey, 'Philosophy of experiment in early modern England: The case of Bacon, Boyle and Hooke', *Early Science and Medicine*, 19, 2014, pp. 103–32, and Sections 5.2, 5.4, and 5.5 draw on Anstey, 'Bacon, experimental philosophy and French Enlightenment natural history', in *Natural History in Early Modern France: The Poetics of an Epistemic Genre*, eds. Raphaële Garrod and Paul J. Smith, Leiden: Brill, 2018, pp. 205–40 with permission from Brill. Section 5.6 draws on Anstey, 'D'Alembert, the "Preliminary Discourse" and experimental philosophy', *Intellectual History Review*, 24, 2014, pp. 495–516 with permission from Taylor & Francis. Sections 7.1, 7.2, and 7.3 draw on Vanzo, 'Christian Wolff and Experimental Philosophy', *Oxford Studies in Early Modern Philosophy*, 7, 2015, pp. 225–55 with permission from Oxford Publishing Limited. Section 7.4 draws on Anstey, 'The four classes of the Berlin Academy', in *The Berlin Academy in the Reign of Frederick the Great: Philosophy and Science*, eds. Tinca Prunea-Bretonnet and Peter R. Anstey, Oxford University Studies in the Enlightenment, Liverpool: Liverpool University Press, 2022, pp. 17–38. Chapter 8 draws on Vanzo, 'Kant on empiricism and rationalism', *History of Philosophy Quarterly*, 30, 2013, pp. 53–74 with permission from *History of Philosophy Quarterly*. Section 9.1 draws on Vanzo, 'From empirics to empiricists', *Intellectual History Review*, 24, 2014, pp. 517–38 with permission from Taylor & Francis.

A NOTE ON CITATIONS

Aristotle's works are cited with the title, followed by the Bekker numbers. Quotations are from Aristotle 1984.

The *Critique of Pure Reason* is quoted with the page numbers of the first edition of 1781 ('A') and of the second edition of 1787 ('B'). Other writings by Kant are cited with the title (sometimes in an abbreviated form), followed by the volume and page number of the Academy Edition (Kant 1900–). Citations from Kant's *Reflexionen* also indicate each *Reflexion*'s number and the dating established by Adickes (sometimes in a simplified form). Translations are our own for those writings of Kant which have not been translated into English. All other translations are from the *Cambridge Edition of the Works of Immanuel Kant* (Kant 1992–). American spelling has been replaced with British spelling in quotations.

Italics in quotations are original, underlinings are added. All translations are our own unless otherwise specified.

ABBREVIATIONS

Bodl.	Bodleian Library
ESD	Experimental/speculative distinction
MS/S	Manuscript/s
OED	*Oxford English Dictionary*
RED	Rationalism/empiricism distinction

Jean Le Rond d'Alembert

PD	*Preliminary Discourse to the Encyclopedia of Diderot*, trans. Richard N. Schwab, Chicago: University of Chicago Press, 1995. First published as 'Discours préliminaire des éditeurs', in *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers*, eds. Denis Diderot and Jean Le Rond d'Alembert, vol. 1, Paris, 1751.

Francis Bacon

OFB	*The Oxford Francis Bacon*, eds. Graham Rees et al., Oxford: Clarendon Press, 1996– . Cited by volume number and page number, for example, OFB 11 103.
SEH	*The Works of Francis Bacon*, 7 vols., eds. James Spedding, Robert L. Ellis, and D. D. Heath, London: Longmans and Co., 1857–74. Cited by volume number and page number, for example, SEH 4 104.

Robert Boyle

B	*The Works of Robert Boyle*, 14 vols., eds. Michael Hunter and E. B. Davis, London: Pickering and Chatto, 1999–2000. Cited by volume number and page number, for example, B 4 104. Short titles of Boyle's individual works are used throughout the text.
Boyle Corr.	*The Correspondence of Robert Boyle*, 6 vols., eds. Michael Hunter, Antonio Clericuzio, and Lawrence M. Principe, London: Pickering and Chatto, 2001.

Denis Diderot

Pensées	*Pensées sur l'interprétation de la nature*, Amsterdam, 1754.

Denis Diderot and Jean Le Rond d'Alembert

Encycl. *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers*, eds. Denis Diderot and Jean le Rond d'Alembert, University of Chicago: ARTFL Encyclopédie Project (Spring 2021 ed.), eds. Robert Morrissey and Glenn Roe, http://encyclopedie.uchicago.edu/. First published Paris, 1751–72.

David Hume

Treatise *A Treatise of Human Nature*, vol. 1, eds. David F. Norton and Mary J. Norton, Oxford: Clarendon Press, 2007 (1st ed., 3 vols., London, 1739–40).

Immanuel Kant

A … /B … *Kritik der reinen Vernunft*, Riga: Hartknoch, 1st ed. 1781 ('A'), 2nd ed. 1787 ('B'), ed. Jens Timmermann, Hamburg: Meiner, 1996.

Entd. *Über eine Entdeckung, nach der alle neue Kritik der reinen Vernunft durch eine ältere entbehrlich gemacht werden soll*, in Kant 1900–, vol. 8, pp. 185–251.

Fort. *Welches sind die wirklichen Fortschritte, die die Metaphysik seit Leibnizens und Wolff's Zeiten in Deutschland gemacht hat?*, in Kant 1900–, vol. 20, pp. 253–351.

KpV *Kritik der praktischen Vernunft*, in Kant 1900–, vol. 5, pp. 1–163.

KU *Kritik der Urteilskraft*, in Kant 1900–, vol. 5, pp. 165–485.

Prol. *Prolegomena zu einer jeden künftigen Metaphysik, die als Wissenschaft wird auftreten können*, in Kant 1900–, vol. 4, pp. 253–383.

Refl. *Reflexionen* from *Kant's Handschriftlicher Nachlaß*, in Kant 1900–, vols. 14–19.

G. W. Leibniz

New Essays *New Essays on Human Understanding*, trans. Peter Remnant and Jonathan Bennett, Cambridge: Cambridge University Press, 1996.

John Locke

Essay *An Essay concerning Human Understanding*, ed. Peter H. Nidditch, Oxford: Clarendon Press, 1975.

Isaac Newton

Newton Corr. *The Correspondence of Isaac Newton*, 7 vols., eds. W. H. Turnbull et al., Cambridge: Cambridge University Press, 1959–77.

Principia *The Principia: Mathematical Principles of Natural Philosophy*, eds. and trans. I. Bernard Cohen and Anne Whitman, Berkeley: University of California Press, 1999.

Henry Oldenburg

Oldenburg Corr. *The Correspondence of Henry Oldenburg*, 13 vols., eds. A. R. Hall and M. B. Hall, Madison, Milwaukee, and London: University of Wisconsin Press, Mansell, and Taylor & Francis, 1965–86.

Introduction

This book is a history of the emergence, flourishing, and eclipse of experimental philosophy in the early modern period. Experimental philosophy was one of the most significant developments in early modern philosophy. It arose as a movement among natural philosophers in England in the 1660s and quickly spread to English medicine. It was soon embraced in Italy and was taken up in the second decade of the eighteenth century in the Netherlands, and then in the 1730s in France. In the mid-eighteenth century, a number of Scots philosophers applied its methods to moral philosophy, and even to aesthetics and political philosophy. It had a significant impact in Germany in the mid-eighteenth century, and it features in histories of philosophy up until the early nineteenth century. In short, early modern experimental philosophy was a sustained, far-reaching, and complex historical phenomenon.

However, experimental philosophy hardly features at all in today's undergraduate courses on seventeenth- and eighteenth-century philosophy. There are a number of reasons for this omission, and some of them are discussed in Part III. Yet our primary aim here is not to explain why experimental philosophy has been overlooked, but to provide a general history of early modern experimental philosophy, a history that we hope will act as a springboard for further research and will impact on the way in which early modern philosophy is understood and taught in our universities.

Of course, this short history of experimental philosophy does not pretend to be comprehensive. What it attempts to do is to trace the rise and fall of experimental philosophy throughout the seventeenth and eighteenth centuries. The broad historical sweep of experimental philosophy is discussed and interpreted along three interlocking parameters: philosophical, disciplinary, and geographical. Thus, we discuss the emergence and development of experimental philosophy as a response to a cluster of philosophical problems concerning our knowledge of nature and ourselves within it. We discuss the spread of experimental philosophy from the discipline of natural philosophy to the discipline of medicine and other cognate fields, and then to moral philosophy. We treat of the different manifestations of experimental philosophy across various disciplines as they appeared in Britain and the Continent throughout

the period. And we trace the decline of experimental philosophy in late eighteenth-century Germany.

The history of experimental philosophy is patchy and uneven. It was not a movement that swept all before it or that manifested itself in a predictable chronological, disciplinary, or geographical sequence. It was a movement that had its allies and its enemies, its triumphs and failures, and there is, perhaps, no master narrative that enables us to capture every facet of its variegated nature. What we offer in this history, over and above the charting of the main points of its historical manifestation and the views of its major protagonists, is an account of the internal conceptual drivers that led to development and change within the movement. We have also attempted to isolate many of the context-specific factors that account for the idiosyncrasies of its manifestations in different countries, institutions, and protagonists.

The English term 'experimental philosophy' and the Latin equivalent *philosophia experimentalis* were occasionally used before the emergence of the movement in the 1660s. They are found, for instance, with a range of connotations in the Hartlib Papers and other correspondence.[1] The earliest known use of the term in English appears to be 1634 in Samuel Hartlib's *Ephemerides*.[2] It is normally associated with natural philosophy and often with the thought and writings of Francis Bacon.[3] Thus, in 1634 we find John Drury speaking of 'Philosophiae Experimentalis Verulamianus' (Bacon's experimental philosophy). By the early 1660s, however, the term was in regular use. Robert Boyle used it in *Spring of the Air*,[4] published in early 1660, and in the title of his *Of the Usefulness of Experimental Natural Philosophy* of 1663. From this period, the meaning of the term becomes fairly stable.

'Experimental philosophy' in its most general sense refers to a method for acquiring knowledge in the study of nature that gives priority to experiment and observation over theory and speculation. We will have much to say about each facet of this core claim of experimental philosophy in the ensuing chapters: its origins in natural philosophy, its prioritising of experiment and observation over theory, and the relation of experiment to theory. What is important here is that, while the disciplinary domain in which it was applied varied, and while there are a variety of context-specific meanings of the term, the kernel of experimental philosophy – its prioritising of experiment and observation over theory in acquiring knowledge of nature – remained constant. We ought also to point out here that many experimental philosophers

[1] See Feingold 2016.

[2] Hartlib Papers, 29/2/11A. Hartlib appears to be quoting the Cambridge scholar William Watts, though it may be Hartlib's own expression. See Feingold 2016, p. 3.

[3] See, for example, what Mordechai Feingold (2016, p. 4) claims is the earliest appearance of the term in print in the dedication of Gilbert Watts' edition of Bacon's *Advancement of Learning*, Bacon 1640, sig. ¶2^{v}.

[4] B 1 143.

did not draw a systematic distinction between experiment and observation but rather treated the expression 'observation and experiment' as a hendiadys.[5] So, in the chapters that follow, we shall use the expressions 'experimental evidence', 'observational evidence', and 'empirical evidence' as synonyms.

It is clear, then, that early modern experimental philosophy is quite a different phenomenon from contemporary experimental philosophy, or x-phi as it has come to be abbreviated. (We refer to contemporary experimental philosophy as x-phi and reserve 'experimental philosophy' for the early modern movement that is the focus of this book.) X-phi is often characterised, in a narrow sense, as the application of empirical methods from psychology and the social sciences to investigate people's intuitions and, in a broader sense, as the use of empirical methods to investigate philosophical questions.[6] Early modern experimental philosophers were not typically concerned with the empirical or experimental investigation of intuitions. However, like practitioners of x-phi in the broader sense, they did hold that observation and experimentation play a crucial role in philosophical inquiry – including both those branches of philosophical inquiry, like natural philosophy, that now belong to natural sciences and those branches, like ethics, that are still regarded as philosophical *stricto sensu*. Early modern experimental philosophy, then, is a distant relative of x-phi. Just how much continuity there is between the two should become clearer as the history of the earlier movement unfolds in the following chapters.[7]

Experimental philosophy should be also distinguished from the notion of empiricism that, along with rationalism, looms large in twentieth- and twenty-first-century histories of early modern philosophy. While the recent literature has witnessed the appearance of several alternative characterisations of empiricism,[8] along with distinctions between kinds of empiricism, many historians of early modern philosophy still adopt what we will argue is the original, Kantian characterisation of empiricism. This is the conjunction of two claims:

[E1] all human concepts derive from experience, and
[E2] all substantive human knowledge can only be proven to be true a posteriori.[9]

[5] For further discussion, see Daston 2011; Malik 2017.
[6] See Sytsma 2017.
[7] See also Anstey and Vanzo 2016, pp. 98–9; Sorell 2018.
[8] For unorthodox definitions of empiricism or rationalism, see, for example, Specht 1979, p. 15; S. Brown 1985, pp. 195, 198; Carruthers 1992, pp. 129–30; Garrett 1997, pp. 29–38; Ayers 2005. For further discussion of forms of empiricism, see the Conclusion, pp. 289–93.
[9] Several notions of empiricism can be found in Kant's writings. This notion of empiricism corresponds to the Kantian notion that we designate as 'history-empiricism' in Section 8.2. In support of the claim that this notion of empiricism originates in Kant's works, see the survey of pre-Kantian uses of empiricism in Vanzo 2014. Characterisations of empiricism in terms of [E1] and [E2] can be found, for instance, in S. Brown 1996b, p. 10 and Priest 2007, p. 5.

Empiricists deny that we have innate concepts or innate principles and that we can have any substantive a priori knowledge. By contrast, rationalists claim that we have innate concepts and that we can have some substantive a priori knowledge.

While some upholders of experimental philosophy, like Locke and Hume, endorsed [E1] and rejected concept innatism, others stressed the role of experience in the acquisition of knowledge while claiming that we have innate ideas. For instance, Robert Boyle endorsed concept innatism, and Lorenzo Magalotti endorsed the Platonic doctrine of recollection in a text strongly aligned with experimental philosophy, the proem of the Accademia del Cimento's *Saggi di naturali esperienze*.[10] Although Locke, who advocated experimental philosophy, famously criticised innate *ideas*, his main target in the first book of the *Essay* was innate *principles*.[11] And the Scots moral philosopher George Turnbull, a vocal proponent of the application of experimental philosophy to ethics, held that the idea of God is innate.[12]

As for [E2], the view that our substantive knowledge can only be proven to be true a posteriori provides a natural underpinning for experimental philosophers' emphasis on the priority of experiments and observations over theory and speculation. However, while [E2] reflects a concern with the *justification* of knowledge claims, experimental philosophers were primarily concerned with the method that we should follow in the *acquisition* of knowledge. Thus, while many experimental philosophers might perhaps be said to be empiricists in a generic, loose sense of the term, the notion of empiricism has a different meaning and reflects different concerns than the notion of experimental philosophy. As we will argue in Chapter 8, these were distinctively Kantian concerns (reflecting his interest in the origin of the categories and synthetic a priori judgements) which post-Kantian authors used as a prism through which to chart the development of early modern philosophy. And whereas early modern empiricists are routinely contrasted with rationalists, there was no homogeneous grouping of speculative philosophers – to use experimental philosophers' preferred designation of their opponents – who provided a counterpoint to the experimental philosophy movement. The notion of speculative philosophy functioned primarily as a rhetorical and argumentative foil for experimental philosophers, and the many critics of experimental philosophers or (more rarely) experimental philosophy as such held a variety of views and motivations.[13]

[10] See Robert Boyle, *The Christian Virtuoso, 1*, B 11 300–1; Magalotti 1667, sig. +1 2. Jean-Baptiste du Hamel, an early French advocate of experimental philosophy, accepted innate ideas. See du Hamel 1672, p. 348.

[11] See Anstey 2013b, p. 315.

[12] Turnbull 2005, pp. 230–5.

[13] Critics of experimental philosophy include, for instance, in England, Bampfield 1677a and 1677b; Hobbes, *Dialogus physicus* (London, 1661), translation in Shapin and Schaffer

Terms have referents, cognates, and semantic fields, and before long the term 'experimental philosophy' referred not simply to a method of knowledge acquisition, but to a movement. When we speak of it as a movement, we mean, following the OED, that it was 'a course or series of actions and endeavours on the part of a group of people working towards a shared goal'.[14] Experimental philosophy was a movement with its central tenets and epistemic values, its leaders, followers, promoters, and opponents; a movement with its own jargon and rhetoric, and eventually its own institutional niches and material culture, and above all its shared goal of practising and promoting a distinctive shared methodological approach in natural philosophy. So, for example, in 1707, Roger Cotes, who later edited the second edition of Newton's *Principia* (1713), was appointed the Plumian Professor of Astronomy and Experimental Philosophy in Cambridge. By the time of Cotes' appointment, courses in experimental philosophy were being taught and 'demonstrated' in Oxford, Cambridge, London, and St Andrews, and the term now connoted the content of these courses. As a result, especially in pedagogical contexts, one could find disciplinary rather than methodological uses of the expression 'experimental philosophy'.[15] Thus, early modern experimental philosophy became a social phenomenon with literary and material outputs and institutional cachet.

All of these facets of early modern experimental philosophy are fascinating and worthy of detailed study in their own right. However, our focus in this history is on, for want of a better word, philosophical aspects of experimental philosophy. It is not that we ignore the institutional, linguistic, and material strands of its history, but this study is centred on experimental philosophy as a phenomenon within early modern philosophy, rather than on its place in the history of science or early modern social history.

1985, pp. 345–91; Cavendish 2001 [1666/8]; Casaubon 1669 (see Spiller 1980); Stubbe 1670a, 1670b, 1670c (see Heyd 1995, chapter 5); Sergeant 1696, esp. sigs. $d5^r$–$d6^r$; and in Italy, Aletino 1694, pp. 189–254 and Barbieri 1752, pp. 1–18. Aletino referred to experimental philosophers interchangeably as 'atomists' and 'experimentalists', as did, among others, one of the Spanish critics of both corpuscularism and experimental philosophy, Juan Martin de Lessaca (1717, p. 7).

[14] OED, meaning 8a.

[15] See Baglivi 1696, part 1, chapter 5, §5. A number of the authors who advocated a *via media* between experimental and speculative philosophy also sometimes used these expressions in a disciplinary sense, to indicate branches of, or approaches to, philosophy that can co-exist or could be combined. See, for example, Cavendish 2001 [1666/8], p. 242 in England and Bartoli 1677, pp. 305–7 in Italy; and in Germany, Wolff's and Tetens' attempts to combine experimental and speculative philosophy, discussed in Chapter 7. In eighteenth-century Germany in the Berlin Academy, experimental and speculative philosophy happily co-existed as separate classes within the institution (see Section 7.4). Later in the century, supporters of experimental philosophy (e.g., Feder 1788, p. 43) as well as others (e.g., Wezel 1784, p. 24) sometimes used 'speculative philosophy' in a non-derogatory way as a synonym of 'theoretical philosophy'.

To that end, it is important at the outset to set out some of the basic distinctions and the broad contours of the philosophical context within which experimental philosophy emerged. As we have established, experimental philosophy involved a method for acquiring knowledge in the study of nature. Its salient feature was that it gave epistemic priority to experiment and observation; however, it was also set within a broader approach to knowledge deriving ultimately from Aristotle's *Posterior Analytics*, what one of us elsewhere has called the neo-Aristotelian theory of knowledge acquisition.[16]

This neo-Aristotelian theory of the acquisition of knowledge held that each science or *scientia*, including natural philosophy, is derived from first principles that take the form of propositions. The question arose then as to how we gain knowledge of the principles of a science. Experimental philosophers insisted that in this process we must give epistemic priority to experiment and observation over and above speculation and theorising. As a result, they set themselves against what they called speculative philosophy, which, in their view, established principles using primarily hypotheses and a priori reasoning, without relying systematically on experiment and observation. A concomitant of this prioritising of observation and experiment was that many experimental philosophers spoke of a two-step approach to developing a science of nature. According to them, it is only after the initial process of gathering experimental and observational evidence is well under way that we can firmly commit to principles and theories, and theorising begins with the attempt to determine the true principles of a science.

The second structural feature of the neo-Aristotelian theory of knowledge that pertains to the history of experimental philosophy is that it divided knowledge into two distinct forms, practical knowledge and speculative knowledge. This feature is crucial for understanding the origins of the distinction between experimental and speculative philosophy, a distinction that characterises early modern experimental philosophy from its beginnings (see Chapter 1). It is conceivable that early modern experimental philosophy could have arisen without defining itself against speculative philosophy. In other words, there could have been experimental philosophy without the experimental/speculative distinction (hereafter ESD). However, this is not

[16] See Anstey 2020. For early modern theories of principles, see Blundeville 1617, Pascal 1995 [1670], Arnauld and Nicole 1996 [1683], Mariotte 1678, Barrow 1734 [1683], and d'Alembert and Chapelle 1755. If we take Newton as an exemplar: for his general principles, see his 'Principles of Philosophy' in McGuire 1970, pp. 182–4 and commentary in K. Walsh 2017; for his deployment of principles in hydrostatics, see the manuscript known as *De gravitatione* in Newton 2014, pp. 50–8 and commentary in Chalmers 2017, chapter 9; for his deployment of principles in optics, see Newton 1979 [1730], and for analysis, see Worrall 2000.

how things worked out, and the ESD remained a central feature of experimental philosophy and a key polemical driver of the movement until the end of the eighteenth century.

In fact, this distinction became one of the standard terms of reference in early modern natural philosophy and philosophy more generally. It had a long prehistory insofar as the distinction between experimental and speculative is a descendant of the distinction between practical and speculative knowledge found as far back as Aristotle. In its early modern form, however, the distinction is primarily methodological:[17] experimental philosophy emphasised the priority of observation and experiment over theory and speculation. By contrast, speculative philosophy began with principles and hypotheses from which systems of knowledge were constructed, and – in the eyes of experimental philosophers – it only paid lip service to observation and experiment. We have set out this philosophical context in Figure 1.1 which shows in a simplified way the manner in which core features of experimental philosophy arose out of the Aristotelian theory of knowledge.

There is another aspect of early modern experimental philosophy that, like the ESD, was non-essential but features prominently in the practice of experimental philosophers in its first four decades. This is their

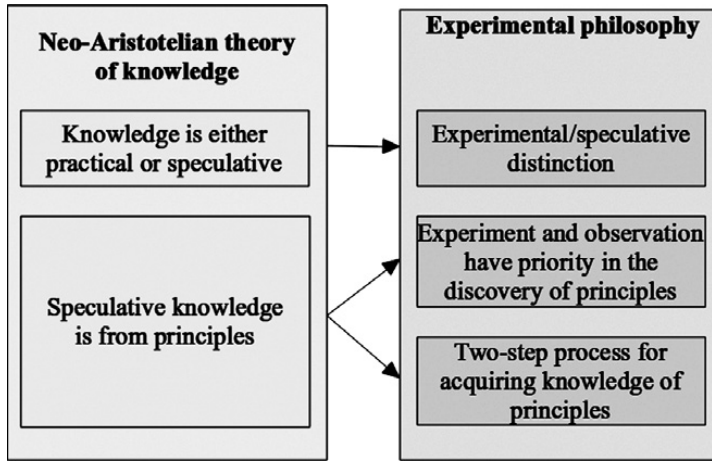

Neo-Aristotelian theory of knowledge
Knowledge is either practical or speculative
Speculative knowledge is from principles
Experimental philosophy
Experimental/speculative distinction
Experiment and observation have priority in the discovery of principles
Two-step process for acquiring knowledge of principles

Figure 1.1 Experimental philosophy and its relation to the neo-Aristotelian theory of knowledge

[17] However, see note 15 above on disciplinary uses of the distinction.

commitment to Francis Bacon's architectonic vision for a natural philosophy founded upon natural histories, which was the main inspiration for the practice of and theorising about experimental philosophy. This need not have been the case, and, in fact, the Baconian approach to natural history moved well into the background in the theory and practice of experimental philosophy from the end of the seventeenth century (see Chapter 3). We regard the strong emphasis on natural history among the first generations of experimental philosophers as deriving in large part from the philosophy of Bacon himself, and a concomitant Baconian legacy was the philosophy of experiment that we find in the writings of Robert Boyle and Robert Hooke. Again, this is a contingent feature of early modern experimental philosophy: the movement could well have progressed in the absence of a carefully articulated philosophy of experiment. Nevertheless, as things transpired, a philosophy of experiment did form part of the theoretical background to the movement as it developed in the latter decades of the seventeenth century (see Chapter 3).[18]

The ESD provides a kind of entry point into a number of philosophical problems around which we have shaped this book. It is, in a sense, the popular framing of a clutch of deeper philosophical issues that beset early modern thought in general and which became the conceptual drivers in the emergence and development of experimental philosophy. Each of these problems has to do with understanding the inner nature, structure, and behaviour of things in the world. As such, they are both metaphysical and epistemological problems. They were not new problems, but experimental philosophers, we will argue, tackled them in new ways. The first has to do with the nature of things themselves. It is the problem of inner natures or essences. Many philosophers believed that particular substances such as gold, or qualities such as heat, have an essential nature, something in virtue of which it is what it is. Furthermore, they believed that these essences are the same for all tokens of the same type, and that knowledge of these essences will lead to an understanding of the behaviour of that type of thing and their relations with other types of thing: all gold has the same essence and interacts with other substances in the same ways. The problem was to get epistemic access to the essences. Can this be gained through the senses, through reason, or through a combination of both?

Experimental philosophers claimed not just that knowledge of inner natures ought to be obtained via the senses, but that the acquisition of this knowledge required more than this: it required structured experiment and observation. They also claimed that experiment and observation had temporal and epistemic priority over speculation in the search for essences. In their view, anyone who denied this and claimed that reasoning from speculative theories

[18] See also Anstey 2014a.

and hypotheses was the place to start in the discovery of the inner natures of things was a speculative philosopher.

Once those essences were known, there was then a second problem as to how to construct a body of knowledge concerning them, their behaviour, and their relations with other things. As we have argued, at the turn of the seventeenth century there was a well-established theory as to how to go about this deriving from Aristotle's *Posterior Analytics*. While there were variants of the theory, the general view was as follows. In order to generate a science, we need to start with principles: both the common propositional principles that pertain to all sciences and those certain propositions about the essences of things pertaining to the science at hand. Once the principles are established, we then proceed, using a method of demonstration such as the Aristotelian syllogistic, from these common and proper principles to produce a systematic body of knowledge.

Experimental philosophers were committed to this neo-Aristotelian theory of knowledge acquisition and yet were aware of its limitations. In addition to the problem of knowing the essences of things, there is a difficulty in determining what the principles are, and, furthermore, there are various issues with the process and outcomes of developing a demonstrative science. Many experimental philosophers opposed the foundational role of a priori principles and harshly criticised the leading examples of this sort of demonstrative science. Aristotelian natural philosophy and Cartesianism were two of the most criticised speculative philosophies.[19]

This leads us to the third and closely related philosophical problem that experimental philosophers sought to address, namely, establishing the precise relation between observation and experiment on the one hand, and theorising using principles and hypotheses on the other. For, even if we come to know the essence of a particular substance or quality, the question remains: in the process of constructing the relevant science, how should we relate observations and experiments to theory? On the whole, experimental philosophers decried the use of hypotheses and premature theorising on the basis of principles, especially when these were used without sustained recourse to observation or experiment.

It is one thing to say that natural philosophers ought to carry out observations and perform experiments rather than merely spinning theories out of their own minds; it is far more difficult actually to specify what the standards of

[19] There were, however, some attempts by early supporters of experimental philosophy to recruit Descartes among the predecessors of or contributors to experimental philosophy. See, for example, Glanvill 1665, p. 72; Accademia dei Fisiocritici 1691, §31; and Conti 1832, p. 76 (Conti also acknowledges Descartes' contributions to speculative philosophy, pp. 88–90). It is worth noting the irony in the fact that many experimental philosophers were working with the neo-Aristotelian theory of knowledge acquisition in order to establish an anti-Aristotelian natural philosophy.

adequacy for observation and experiment are, either in general or with respect to any particular natural philosophical theory or principle. Experimental philosophers were quick to criticise the method of speculation insofar as it lacked adequate recourse to observation and experiment, but what quantity and kinds of experimental evidence are sufficient for establishing theories?

In addressing this question, it is helpful to distinguish between the intrinsic and extrinsic epistemic value of observational and experimental evidence. The intrinsic epistemic value of some determinate experimental evidence is the degree to which that evidence is reliable or can be trusted in its own right. The extrinsic epistemic value of some, say, experimental result depends on the evidential relation between the result and something else, such as a theory or proposition. In the case of the *intrinsic* epistemic value of empirical evidence, the early moderns attempted to establish reliability through repetition and replication of experiments, through methods of variation (see Section 2.4), and through testimony, especially the number and credibility of witnesses.[20] Each of these approaches finds parallels in contemporary science. However, with regard to the *extrinsic* value of observational and experimental evidence, there is an important difference between most early moderns and contemporary scientific practitioners.

There are many uses of observational and experimental evidence, including saving the phenomena; testing, developing, and calibrating instruments; exploratory experiments, and so on. However, in contemporary science the primary way in which the *extrinsic* epistemic value of observational and experimental evidence is gauged is the extent to which it *confirms or disconfirms scientific theories*. This was not the case in the early modern period. In the seventeenth and eighteenth centuries, the primary way in which the *extrinsic* epistemic value of observational and experimental evidence was assessed was the extent to which it facilitated the establishment of the *foundational principles* of a science. It was believed that once those principles were established – whether they be axioms, definitions, or laws of nature – one could proceed to develop the theory. To be sure, observational and experimental evidence were used for other purposes, such as testing and calibrating instruments and saving the phenomena. Moreover, there are examples of early modern experiments which with hindsight we can describe as confirming or disconfirming theories, testing hypotheses, or using experimental evidence in inferences to the best explanation. Yet it was the role of empirical evidence in establishing the

[20] For the repetition and replication of experiments in the early modern period, see Schickore 2010, 2011, 2017; Steinle 2016b. For Boyle on the utility of experimental replication, see Royal Society Boyle Papers, vol. 9, fol. 12^{r}; and for Boyle on experimental repetition and variation, see Sargent 1995, pp. 176–80. For an early reference to replication in Hooke that takes its inspiration from Bacon, see his 1661, p. 41. For testimony and witnessing of early modern experiments, see Shapin and Schaffer 1985; Shapin 1994; B. Shapiro 1999; Serjeantson 2006; and Hogarth and Witmore 2020.

principles of a science that was paramount. When experimental philosophers charged speculative philosophers with developing their systems or theories without adequate recourse to observation and experiment, they were effectively claiming that the principles on which their speculative theories were founded might conflict with experimental evidence and/or might arise from prepossession or dogmatism, rather than an objective appraisal of available empirical evidence. Here is how Newton expressed it a manuscript note on analysis and synthesis, *c*. 1704:

> [Analysis consists in] examining the truth of those conclusions by new experiments & drawing new conclusions . . . from those experiments & so proceeding alternately . . . untill you come to the general properties of things . . . Then assuming those properties as Principles of [natural] Philosophy you may by them explain the causes of such Phaenomena as follow from them . . . But if . . . you feign Hypotheses . . . your systeme will be little better than a Romance. (McGuire 1970, p. 185)

To take a widely discussed example, Descartes' natural philosophy was founded on the principle that extension is the primary attribute of matter, a principle that entails empty space is impossible. Yet from the time of Torricelli's discovery of the suspension of a mercury column in the eponymous Torricellian apparatus in 1644, to Boyle's air-pump experiments which were published in 1660, the body of empirical evidence suggesting the existence of partial vacuums was growing. Experimental philosophers claimed that the veracity of Descartes' principle needed to be considered in the light of this new evidence, rather than interpreting this evidence in the light of the principle.[21]

This is not to say that experimental philosophers denied any role for reason in the establishment of principles of natural philosophy. Indeed, their warnings against prepossession entail an acknowledgement of the danger of what we now call the theory ladenness of observation, though there is little evidence of an awareness among them of the extent to which tacit concepts and theories have a role in structuring sensory perception. Both Hooke and Boyle discuss the relation between empirical evidence and reason. Thus, in his *General Scheme* for improving natural philosophy, Hooke speaks of how the discovery of the inner natures of bodies 'will require much deeper Researches and Ratiocinations, and very many Vicissitudes of Proceedings from Axiomes to Experiments, and from Experiments to Axiomes' (Hooke 1705b, p. 61).

The relationship between experimental philosophy and speculative philosophy was, more often than not, one of antagonism. However, a number of

[21] See, for example, Boyle, *Spring of the Air*, B 1 198; Locke, Draft A, §27, Locke 1990, pp. 45–6 and *Essay* IV. vii. 12–13; John Keill 1720, p. 16–17. For plenist interpretations, see, for example, Le Grand 1673, pp. 14–15; Leibniz in *The Leibniz–Clarke Correspondence*, Alexander 1956, pp. 64–6.

leading experimental philosophers, such as Robert Boyle and Robert Hooke, were more conciliatory and posited a kind of mutual feedback relation between experiment and theory. At first glance, this might seem paradoxical; however, it is important to note that, as with the term 'experimental philosophy', the term 'speculative philosophy' could have either a methodological or a disciplinary connotation. Boyle and Hooke consistently opposed the method of speculative philosophy but were more open than others to engaging with speculative doctrines.

This brings us to the fourth philosophical problem that was integral to the development, indeed the evolution, of experimental philosophy at this time, namely, the respective roles of natural history and mathematics in the processes of acquiring knowledge of essential natures and of constructing a science from that knowledge. The applications of natural history and mathematics were, we will argue, integral to experimental philosophers' attempts to solve the first and third problems, the problem of essence and the problems of relating experiment and theory. Indeed, early modern experimental philosophy can hardly be understood without them.

The natural history developed and practised by early modern experimental philosophers was vastly different from any form of natural history that is practised today. This will become clear as we expound the history of experimental natural history below (Chapter 3), but it will be helpful here at least to sketch the nature and place of the sort of natural history that preoccupied experimental philosophers in the seventeenth and early eighteenth centuries.

Natural history was established as a discipline in the late Renaissance. To be sure, it had a long and distinguished pedigree stretching back to Dioscorides and Pliny the Elder in ancient times. However, as Brian Ogilvie has shown, in the fifteenth and sixteenth centuries it became a discipline of study in its own right as the 'science of describing' natural kinds, with special focus on biological kinds.[22] It was only in the late sixteenth century that natural historians began to be concerned with the classification of natural kinds, that is, with establishing families and hierarchies of biological kinds. Thus, Renaissance natural history developed into 'classificatory natural history' in the seventeenth century and beyond. This classificatory natural history grew apace and reached its zenith in the mid-eighteenth century in the work of Carl von Linné (Linnaeus). Yet, none of this captures the leading ideas and practices of experimental philosophers. For they developed an alternative, far more broad-ranging form of natural history which we call Baconian or experimental natural history.

Baconian natural history had within its remit all bodies from the celestial to the subterranean. It was an architectonic project of fact gathering and fact ordering that pertained not simply to biological kinds, but to all substances,

[22] See Ogilvie 2006.

qualities, states of bodies, and processes. To that end, it happily subsumed the various projects of classificatory natural history, just as it embraced and promoted the sort of chorographical histories of countries and regions that were popular in the period, such as Robert Plot's *Natural History of Oxford-Shire* (1677). Thus, Robert Boyle, one of its leading exponents, produced natural histories of cold, mineral waters, the air, human blood, and fluidity and firmness,[23] all subjects that had no place in and were of no interest to those who practised classificatory natural history. This Baconian form of natural history, we contend, was developed specifically to address the philosophical problems that we have sketched in this introduction and which we believe provide the conceptual drivers for the emergence and development of experimental philosophy. Without it, our understanding of early modern experimental philosophy would be significantly impoverished. But more of that anon.

Mathematics also played a pivotal role in the development of experimental philosophy. The scientific status of mathematics and its relation to natural philosophy were controversial topics in the sixteenth and seventeenth centuries, yet, at the same time, mathematics underwent very significant advances during the period, including the development of algebra and the invention of the calculus. For many, Euclidean geometry figured as a kind of epistemic ideal of what a demonstrative natural philosophy should be, while for others it seemed to have limited utility. As our story unfolds, we show how in the early eighteenth century a mathematical form of natural philosophy in a very real sense replaced Baconian natural history as the leading method by which experimental philosophy was practised and promoted. Thus, the history of experimental philosophy is entwined with both the history of natural history and of mathematics.

The chapters that follow progress roughly chronologically, and the geographical range of the book gradually fans out from England to the Netherlands, France, and finally Germany.[24] The book has three parts. The first part covers the rise of experimental philosophy with a special focus on the British Isles. Chapter 1 concerns the origins of the ESD. Chapter 2 traces the emergence and development of experimental philosophy in England from the 1650s to the end of the seventeenth century and its early impact in Italy and France, as well as the ways in which it was taken up in medicine and religion. Chapter 3 provides a history of the rise and decline of Baconian or experimental natural history as a way of practising experimental philosophy.

Part II covers the heyday of experimental philosophy. Chapter 4 continues the chronological narrative, covering the emergence and spread of the new

[23] See *New Experiments and Observations Touching Cold, Or An Experimental History of Cold Begun* (1665), B 4; *Short Memoirs for the Natural History of Mineral Waters* (1685), B 10; *The General History of the Air* (1692), B 12; *Memoirs for the Natural History of Humane Blood* (1684), B 10; *The History of Fluidity and Firmness* (1661), B 2.

[24] We do not discuss the impact of experimental philosophy in Italy (see, e.g., Vanzo 2016b, 2019), Ireland (see Hemmens 2015), or Spain (see, e.g., Feijóo y Montenegro 1733).

mathematical approach to experimental philosophy which found its model in the writings of Isaac Newton. Chapter 5 traces the spread of natural philosophy to France from the 1730s. Chapter 6 examines the application of the method of experimental philosophy to moral philosophy in Scotland in the writings of David Hume, George Turnbull, and others.

Part III of the book turns to the question of why, if experimental philosophy was such a wide-ranging and influential philosophical movement, its very existence is only known by specialists and is rarely mentioned in histories of early modern philosophy. We focus on developments in eighteenth- and early nineteenth-century Germany, where the eclipse of experimental philosophy as a distinctive *historical* movement was intertwined with the rise of the *historiographical* notion of empiricism. This is the notion through which many of the key exponents of and developments in early modern experimental philosophy have typically been interpreted in the recent historiography.

In Chapter 7, we argue that experimental philosophy was influential in Germany in both the first and second halves of the eighteenth century. At the turn of the nineteenth century, as Kantian and post-Kantian philosophies rose in popularity, a priori methods found widespread acceptance, and experimental philosophy fell out of fashion. In Chapters 8 and 9 we argue that, at the same time, Kant and his disciples introduced the dichotomy of rationalism and empiricism (hereafter RED). This quickly found widespread acceptance and provided the basis for the RED-centred narrative of early modern philosophy (referred to henceforth as the standard narrative) which has been popularised by works such as Bertrand Russell's *A History of Western Philosophy* (1945) and in the relevant volumes of Frederick Copleston's *A History of Philosophy* (1946–75) and can be found in a large number of recent texts, including multi-volume histories of early modern philosophy,[25] anthologies,[26] and surveys for students and laypeople,[27] as well as studies on specific topics and movements.[28] An account of early modern philosophy revolving around the RED was first sketched by Karl Leonhard Reinhold, who drew on Kantian notions, and then turned into fully fledged histories of early modern thought in the works of two early Kantian historians, Wilhelm Gottlieb Tennemann and Johann Gottlieb Buhle. Thus, in Germany, the decline of experimental philosophy and the eclipse of the ESD went hand in hand with the rise of Kantianism and the development of a historiography based on the RED.[29]

[25] Parkinson 1993; S. Brown 1996a.
[26] R. Copenhaver 2013.
[27] Shand 1993; Francks 2003; Scruton 2002.
[28] Thomas 2009; Huenemann 2008.
[29] On the spreading of the standard narrative of early modern philosophy in English-speaking countries, see Vanzo 2016a. The last book-length histories of philosophy published in English which gave pride of place to experimental philosophy were Morell 1827 and D. Stewart 1854 [1815–21], which was reprinted until 1877. The entry

We do not discuss the decline of experimental philosophy outside of Germany, nor do we take a stand as to whether outside of Germany, too, the decline of experimental philosophy coincided with the rise of the standard narrative.[30]

We hope that, by tracing the development of experimental philosophy, this study might contribute to the formulation of accounts of early modern thought which are more nuanced and explanatorily adequate than the standard narrative, and we reflect on these historiographical implications in the Conclusion. There, we provide answers to our critics by comparing and contrasting what we take to be the relative merits of the standard narrative and other forms of the RED on the one hand with the ESD on the other. Needless to say, we argue that the ESD has greater explanatory power and that there are good reasons for claiming that the RED no longer earns its keep.

'experimental philosophy' appeared in the *Encyclopedia Britannica* from the second edition of 1778. It was substantially shortened in the seventh edition of 1842 and removed in the ninth edition of 1889. See Gómez 2012b.

[30] It took another century for that historiography to become the standard historiography of early modern thought in the English-speaking world. See Vanzo 2016a.

PART I

The Rise of Experimental Philosophy

CHAPTER 1

The Origins of the Experimental/Speculative Distinction

From the mid-1660s in England, natural philosophy increasingly came to be understood as being practised in two quite different ways. It could be done either according to the new experimental philosophy or according to speculative philosophy. This is nicely summed up in John Dunton's student manual of 1692 in the following terms: 'Philosophy may be consider'd under these two Heads, Natural and Moral: The first of which, by Reason of the strange Alterations that have been made in it; may be again Subdivided into *Speculative* and *Experimental*.'[1] While natural and moral philosophy were different branches of philosophy, experimental and speculative philosophy were competing methodologies in the field of natural philosophy. The opening of John Sergeant's *The Method to Science* (1696) brings this out well: 'The *METHODS* which I pitch upon to examine, shall be of two sorts, viz. that of *Speculative*, and that of *Experimental* Philosophers; The Former of which pretend to proceed by *Reason* and *Principles*; the Later by *Induction*; and both of them aim at advancing *Science*.'[2]

As we have seen, experimental philosophy was originally a method for acquiring knowledge of nature. On the positive side, it emphasised observation and experiment and, negatively, it decried hypotheses and speculation. Experimental philosophers believed that only when a sufficient number of observations and experiments had been performed was the natural philosopher in a position to theorise.[3] Experimental philosophers' opposition to hypotheses and speculation was based, in part, on the danger of prepossession, that is, allowing speculative hypotheses to predetermine the way observation was interpreted.[4] They also

[1] Dunton 1692, p. vi.
[2] Sergeant 1696, sigs. b6^{r-v}.
[3] See, for example, Boyle, *Defence against Linus*, B 3 12.
[4] The point is nicely put by Sir Richard Blackmore in relation to medicine:

> 'tis an Injury to a Man of good sense and natural Sagacity, to be hamper'd with any Hypothesis before he comes to the Practise of Physic. For this prepossession obstructs the Freedom of his Judgement, puts a strong Byass on his Thoughts, and obliges him to make all the Observations that occur to him . . . to comply with, and humour his pre-conceived Opinions.
>
> (Blackmore 1697, p. x)

See also Boyle, *Certain Physiological Essays*, B 2 13 and *Things above Reason*, B 9 373.

criticised the speculative philosophers' lack of recourse to observation, their premature theorising on the basis of speculative hypotheses, and especially the way they constructed systems of natural philosophy.

Unlike experimental philosophers, speculative philosophers were said to proceed from principles and maxims and to reason from them to create natural philosophical theories. These theories might then be checked against observation, but this was often a post hoc element in the process. Speculative philosophers were thought to proceed immediately to demonstrative systems of natural philosophy, rather than commencing with observation and experiment. The most frequent examples of speculative philosophy were Aristotelian and Epicurean natural philosophy and, later, Cartesian natural philosophy.[5]

Experimental philosophy emerged as the dominant way to do natural philosophy in England in the latter half of the seventeenth century, in spite of the attacks of its detractors.[6] And as experimental philosophy gained ascendancy, it began to be applied to other branches of philosophy. Of particular importance is the way it was quickly appropriated by the English chymical physicians and later applied to the human understanding by Locke and others.[7] In the eighteenth century it was extended to all the moral sciences and even aesthetics.[8] Hume sums up this development nicely in the Introduction to his *A Treatise of Human Nature*:

> As the science of man is the only solid foundation for the other sciences, so the only solid foundation we can give to this science itself must be laid on experience and observation. 'Tis no astonishing reflection to consider, that the application of experimental philosophy to moral subjects shou'd come after that to natural at the distance of above a whole century; since we find in fact, that there was about the same interval betwixt the origins of these sciences; and that, reckoning from THALES to SOCRATES, the space of time is nearly equal to that betwixt my LORD BACON and some late philosophers in *England*, who have begun to put the science of man on a new footing. (*Treatise*, pp. 4–5)

Experimental philosophy also experienced a geographical expansion. Denis Diderot and the French *philosophes*, and Johann Nicolaus Tetens and the German popular philosophers saw themselves as experimental philosophers (or, as the Germans used to say, observational philosophers).[9] All of these authors contrasted experimental philosophy with speculative philosophy. For instance, Diderot distinguished

[5] See, for example, Boyle 2008 [1666], p. 2; Hale 1677, pp. 9–10.
[6] See Introduction, note 13 for references.
[7] D'Alembert would later say of Locke, 'he reduced metaphysics ... to the experimental natural philosophy of the soul' (PD, p. 84, modified). For Locke and experimental philosophy, see Anstey 2011a.
[8] On experimental philosophy and aesthetics, see, for example, Turnbull 1740a, pp. 146–8.
[9] See, for example, Diderot 1754; Tetens 1777, 1, pp. iii–iv, vii.

> two kinds of philosophy, the experimental and that based on reasoning. The former has its eyes bandaged, walks always feeling its way, grasps whatever falls into its hands and finds precious things in the end. The other gathers these precious things, and tries to make a torch of them; but this pretended torch has up to the present served it less well than the gropings of its rival, and this must be so.[10]

Along similar lines, German experimental philosophers rejected Kant's 'speculative metaphysics'[11] because it abandoned the experimental approach in favour of 'the most abstract and profound speculations'.[12]

This chapter reconstructs the origins of the distinction between experimental and speculative philosophy, a distinction that pervaded early modern thought, from the debate between Boyle and Hobbes over Boyle's air-pump experiments to the first reception of Kant's Critical philosophy.[13] Where did the ESD come from and how was it established?

The ESD has a long prehistory, a prehistory that goes back at least as far as the medieval period. In fact, in order to set its early history in context we need to go back to Aristotle. Section 1.1 sets out the broad contours of important intellectual shifts in late Renaissance philosophy and medicine that in some ways provided the seedbed from which early modern experimental philosophy arose. In Section 1.2, we examine the traditional classification of natural philosophy as a speculative discipline from Aristotle to the seventeenth century. Section 1.3 surveys some medieval and early modern attempts to articulate an experiential science (*scientia experimentalis*), which aimed to complement speculative natural philosophy. Then in Section 1.4, we turn to certain tensions in the early modern classifications of natural magic and mechanics, which led to the introduction of an *operative*, non-speculative part of natural philosophy in the writings of Francis Bacon and John Johnston. The chapter concludes with a summary of the salient discontinuities between the ESD and its predecessors and a statement of some of the important developments that led to the emergence of experimental philosophy in the mid-seventeenth century.

1.1 Developments in the Late Renaissance

Within the intellectual culture of sixteenth-century Europe, there arose a series of discipline-specific shifts from a strict reliance on authority and reason to an increasing appreciation of the value of experience and observation. The shifts

[10] Diderot, *Thoughts on the Interpretation of Nature*, article XXIII, quoted from Diderot 1937, p. 46.
[11] Platner 1790, preface, sig. a5 5.
[12] Feder 1787, p. xviii. Feder's sketches of the experimental approach can be found on pp. ix–x and in his 1779–93 work, §4.
[13] For further discussion of the ESD in seventeenth-century England, see Anstey 2005.

are evident in astronomy, medicine, and natural philosophy. These developments cannot be compared to generalised 'continental' drift; they were mere fissures and fractures within established and often tightly controlled disciplines. Nevertheless, these changes provided precedents and fertile resources for the later emergence of experimental philosophy in the mid-seventeenth century. Let us examine some of the evidence for them.

In the sixteenth century, if the analysis of Charles Lohr, Eckhard Kessler, and others is correct,[14] the situation with regard to the disciplinary status of natural philosophy was rather complicated and was tied to issues pertaining to the authority of teachers of theology in the Schools. In fact, Lohr identifies two decisive changes which we will set out in terms of the neo-Aristotelian theory of knowledge acquisition. Theologians within the Schools began to emphasise the importance of common principles, that is, principles of metaphysics such as 'Everything that is, is', and their application to the three fields of theology, natural philosophy, and the study of the soul. They brought the latter two under the remit of metaphysics insofar as both the common principles and the proper principles of natural philosophy and the study of the soul were required to generate sciences in those disciplines.[15] This, according to Lohr, was for the general reason that many of Aristotle's principles, such as the eternity of the world, were contrary to Biblical teaching, which, of course, had the status of revelation. According to Lohr, this shift in sixteenth-century natural philosophy represents a break from the authority of Aristotle.[16] Thus, this anti-Aristotelian move in sixteenth-century natural philosophy was tied to theology and, ultimately, ecclesiastical power.

If the general reason for this change was to disown unbiblical principles in natural philosophy, there was also a more immediate and specific reason. For the shift was also a polemical response against the claim of Pietro Pomponazzi that, according to Aristotle's natural philosophical principles, the soul is material.[17] By bringing the study of the soul under the discipline of metaphysics, the Schoolmen were able to hedge off the heretical claims of Pomponazzi and his followers; in effect, the common principles of metaphysics were deployed so as to preclude the possibility of treating the soul as a part of material nature. This shift illustrates the emphasis on metaphysical principles in Renaissance thought that would later come to be regarded as a feature of speculative philosophy.

This brings us to the second, countervailing shift, a shift away from ecclesiastical authority and to the prioritising of experience. A small group of Italian natural philosophers, including Pomponazzi, Girolamo Cardano, and

[14] See Lohr 1988; Kessler 2001.
[15] Lohr 1988, p. 95.
[16] Lohr 1988, p. 99.
[17] See Kraye 2010, pp. 201–3.

Bernardino Telesio, argued, in effect, that the senses were required in order to gain epistemic access to the principles of natural philosophy. And it was on the basis of sensory observations, rather than being subservient to metaphysical principles, that they claimed to have acquired the principles that served as the foundations of their new natural philosophical systems. Thus, Telesio developed a natural philosophy based upon two incorporeal powers, heat and cold, that permeated a homogeneous material substratum and were regulated by a universal sense of self-preservation.[18]

Now, it is important not to overplay the significance of these shifts in the discipline of natural philosophy in the late Renaissance. After all, these *novatores* were only a small group who had little to say about experiment. Nevertheless, they were recognised as innovators by Bacon and later by experimental philosophers, such as Boyle,[19] and no doubt they provided an important precedent in the shift to the prioritising of observation over speculation.

One concrete legacy of these developments, which fed into the emergence of experimental philosophy in the 1650s, is the work of the Jesuit Niccolò Cabeo. In 1646 Cabeo published a commentary on Aristotle's *Meteorology*. The subtitle to this book includes the term *experimentalis philosophia* (experimental philosophy).[20] Cabeo's commentary argues for giving priority to observation and experiment over the authority of Aristotle, and while it remains wedded to a broadly Aristotelian natural philosophy, it does adduce a number of experimental observations that contradict doctrines of the Stagirite.[21]

Concomitant shifts to that found in Cabeo's natural philosophy can be seen in medicine and astronomy. They are also widely acknowledged and no doubt form additional seams of the general background to the emergence of experimental natural philosophy later in the seventeenth century. To point out just one well-trodden path in the historiography, it is no coincidence that Vesalius' *De fabrica* and Copernicus' *De revolutionibus*, both of which appeared in 1543, are often regarded as the *terminus a quo* of the Scientific Revolution, for both works had significant ramifications for subsequent observational anatomy and astronomy, respectively. The importance of observation and experiment in

[18] Van Deusen 1935 provides a good summary of Telesio's natural philosophy.

[19] For Bacon on Telesio, see Giglioni 2010, pp. 160–2. It should be pointed out that, while Boyle regarded Telesio as an anti-Aristotelian innovator, he also classed him as a speculative philosopher. See B 8 95 and B 2 24.

[20] The full title is *In quatuor libros meteorologicorum Aristotelis commentaria, et quaestiones quatuor tomis compræhensa, quibus non solum meteorologica, tum ex antiquorum dictis, tum maxime ex singularum rerum experimentis explicantur sed etiam vniuersa fere experimentalis philosophia exponitur*, Rome, 1646.

[21] For further discussion, see C. Martin 2011, chapter 5 and Dear 2008. For criticism of our earlier treatment of Cabeo in Anstey and Vanzo 2012, see Levitin 2019, pp. 244–5.

anatomy in the medical faculty at Padua in the late sixteenth century is well understood, as is its legacy in the path-breaking experimental work of William Harvey on the motion of the heart and blood in animals. Harvey's work, in turn, was explicitly acknowledged as an exemplar of the use of experiment by early experimental philosophers.

Recent scholarship, however, has added yet another seam to the Renaissance medical context that has a bearing on the emergence of the ESD. This is found in the work by Gianna Pomata and Lorraine Daston[22] on the role of observations in sixteenth-century medicine. Pomata and Daston claim that the proliferation of medical collections of observations from the 1560s, which appeared under the title *Observationes*, signals not merely the emergence of a new 'epistemic genre', but that the concomitant development was the emergence of observation as a new epistemological category. Observation came to have a new role in medicine, connoting both first-hand sensory experience – *autopsia* – and a distaste for hypotheses. Furthermore, Pomata goes so far as to claim that from medicine 'the concept spread to natural philosophy and made its entry into mainstream philosophical language'.[23]

Unhappily, Pomata and Daston do not provide extensive evidence for their claims about the impact of medical *observationes* on mid-seventeenth-century natural philosophy. However, there is ample evidence that the terms 'observation' and 'experiment' began to be coupled around the beginning of the seventeenth century, and this pairing 'experiments and observations' became very common amongst experimental philosophers.[24] Moreover, Daston also claims, 'Baconians played a key role in the rise of the terminology of observation and experiment in mid-seventeenth-century scientific circles',[25] a claim for which we believe there is copious evidence. Whatever the connections between the medical use of *observationes* and natural philosophy, the general semantic developments in the terms 'observation', 'experiment', and their pairing, all signal changes to the kinds of epistemic categories that were being deployed in natural philosophy around the time that experimental philosophy emerged.

1.2 Speculative Natural Philosophy

When seventeenth-century British philosophers began to distinguish between experimental and speculative natural philosophy, they were departing from a centuries-old tradition that regarded natural philosophy as a speculative

[22] See Pomata 2010, 2011a, 2011b, and Daston 2011.
[23] Pomata 2011b, p. 65.
[24] In addition to its title, Boyle's *New Experiments and Observations Touching Cold*, 1665, uses the term 'experiments and observations' twenty-three times.
[25] Daston 2011, p. 83.

discipline. That tradition had its roots in Aristotle's classification of the branches of knowledge. Aristotle proposed that there are three types of knowledge: theoretical, practical, and productive (although he sometimes alluded to a bipartite division between theoretical and non-theoretical types of knowledge). Productive knowledge included rhetoric and art. Practical knowledge concerns how we ought to behave. It included ethics and politics. Theoretical knowledge aims at truth. It included metaphysics and natural philosophy, or the study of nature, as well as mathematics.[26] All of the different branches of knowledge were to be subsumed under this tripartite division (Figure 1.1). Aristotle also distinguished between the practical intellect and the speculative intellect in *De anima* (433^a9–20) and *Nicomachean Ethics* (1139^a1–30).

It would be wrong to think, however, that Aristotle's division of knowledge was the only division to exert an influence up to the time when the ESD emerged. The Stoic division of philosophy into logic, physics (including metaphysics and mathematics), and ethics was well known and adopted by, among others, John Locke.[27] Indeed, philosophers in the Middle Ages,

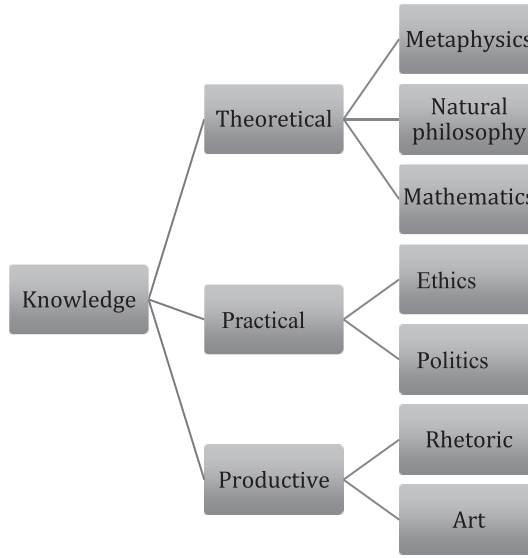


Figure 1.1 Aristotle's division of knowledge

[26] See, for example, *Nicomachean Ethics* 1139^b14–1141^b25; *Topics* 145^a16, 157^a10; *Metaphysics* 1025^b19–27, 1064^a10–19. For the bipartite classification, see *Metaphysics* 981^b25–982^a1; *Eudemian Ethics* 1216^b11–17; *Topics* 152^b2–4. For details, see Mariétan 1901; Barnes 2000, p. 40.

[27] Locke, *Essay* IV. xi. See also Adam Smith 1776, 2, p. 351. The ancient source for this classification is Diogenes Laertius, *Vitae philosophorum*, Diogenes Laertius 1964, VII 40.

Renaissance, and early modern period put forward many alternative classifications besides the Aristotelian and Stoic ones.[28] Joseph S. Freedman holds that divisions of philosophy 'numbered in the thousands during the sixteenth and seventeenth century' alone (Freedman 1994, p. 39). However, the Aristotelian classification and its variations were the most widespread in the early modern period and provided the background for the emergence of the ESD. As examples of Aristotelian classifications, we will consider those of Thomas Aquinas, Franciscus Toletus, and Daniel Sennert.

For Aquinas, there are two objects for the main operations of the rational soul, the good and the true. The former is apprehended by the practical intellect, the latter by the speculative intellect (Figure 1.2; Aquinas 1999 [1265–74], I, 79, 11). The speculative intellect is that aspect of reason which is concerned with the true. The speculative intellect operates using speculative principles, such as 'the whole is greater than the part'. The deliverances of the speculative intellect are necessary truths. The knowledge it generates is speculative knowledge. The practical intellect, by contrast, operates using practical principles, but does not produce necessary truths. This is practical knowledge (III, 94, 4). Aquinas has a lengthy discussion in the *Summa theologica* on the question as to whether the speculative and practical intellects are distinct powers. He is inclined to think that they are not distinct (I, 79, 11).

This simple summary of St Thomas' views is hardly adequate to capture the sophistication of his position, but it is enough to show that in the Western tradition, under the influence of Aristotle, a speculative/practical distinction of *disciplinary domains* found its application in *faculty psychology* in the distinction between speculative and practical intellects, and a concomitant twofold distinction of speculative and practical *knowledge* which, in turn, were founded upon speculative and practical *principles*. Many early modern authors associated disciplinary

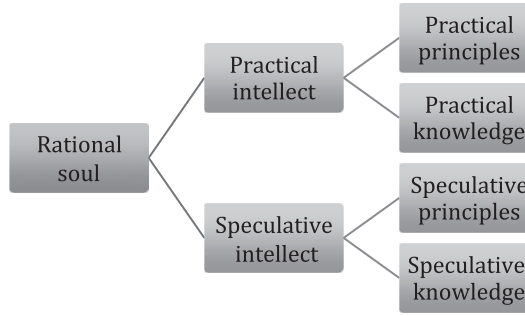


Figure 1.2 Aquinas' practical/speculative distinction

[28] For overviews and further references, see Weisheipl 1965; Blair 2007, pp. 287–93; Freedman 1994; Mikkeli 2001.

domains with mental faculties: among others, Tommaso Campanella;[29] Francis Bacon,[30] the 'Patriark of Experimental Philosophy' (Power 1664, p. 82); and Franco Burgersdijck, the author of a widely used manual.[31]

In the late Renaissance, Franciscus Toletus, a Jesuit philosopher and teacher at the prestigious Collegio Romano, followed Aristotle by dividing philosophy into speculative, practical (operative), and factive (productive) (Figure 1.3). Speculative philosophy consists in metaphysics, mathematics (pure and mixed, or *mathematica media*), and physics. Physics is natural philosophy, and it deals with objects that are perceptible via the senses. Metaphysics deals with the principles and properties that are common to all being. Practical philosophy includes ethics, oeconomy (the study of family management), and politics. Factive philosophy includes the productive arts and is called *mechanica*.[32] Toletus' tripartite distinction is equivalent to Aristotle's division of knowledge into practical, theoretical, and productive.

In the early seventeenth century, the German natural philosopher Daniel Sennert accepted Toletus' partitions of theoretical and practical philosophy

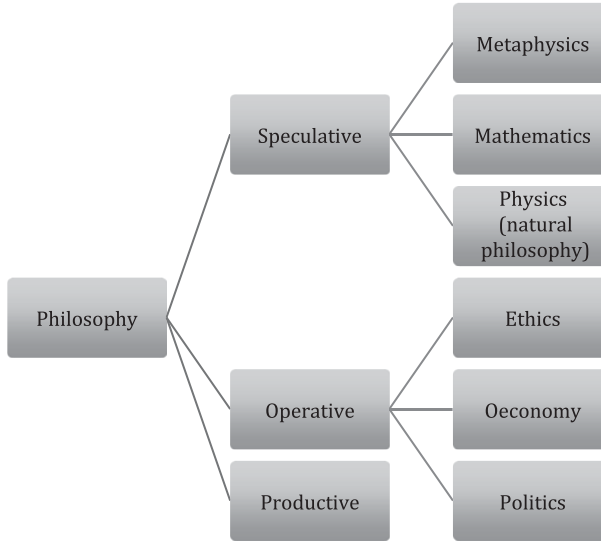


Figure 1.3 Toletus' operative/speculative distinction

[29] See Blanchet 1920, p. 231.
[30] *De dignitate et augmentis scientiarum*, SEH 4 292.
[31] Burgersdijck 1631, p. 2: 'speculative philosophy resides in the speculative intellect ... practical philosophy is related to the practical intellect'. Other authors who associated disciplinary domains with mental faculties are referred to in Tonelli Olivieri 1991, pp. 71–3.
[32] See Toletus 1585, sig. A2 1.

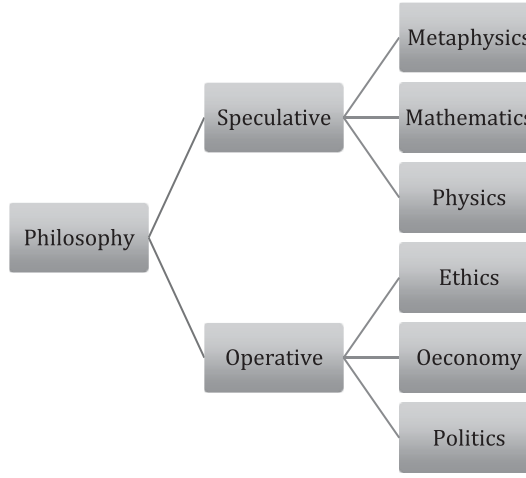


Figure 1.4 Sennert's division of philosophy

(Figure 1.4).[33] However, Sennert criticised Toletus for including the factive disciplines in philosophy because 'they do neither contemplate things divine; nor do they regulate these actions which are proper to Man; nor is honesty the thing they aime at, but Profit, nor does the chief good and Felicity of man consist in them' (Sennert 1618, p. 8; Sennert 1660, p. 3). 'And who is there that dares reckon Smiths, Carpenters, Joyners, Weavers and such like Artificers, amongst Phylosophers?' (Sennert 1618, p. 7; Sennert 1660, p. 3) Instead, Sennert opts for the twofold distinction:

> I, for my part, take that to be the truest division of Phylosophy, which is delivered by *Aristotle* in the Second Book of his *Metaphysics*, Chapter 1. and retained by all sorts of interpreters, viz. into Speculative and Practical. The Speculative part, is that which contemplates all beings or things, with their Principles and Affections or Qualifications, only for knowledg and truths sake: But the practical part of Phylosophy is that whose subject is the Actions of Men. (Sennert 1618, p. 5; Sennert 1660, p. 3)

As for natural philosophy, Sennert holds that it is a science because 'it demonstrates in a necessary subject the proper affections by the proper Causes: as very many demonstrations touching things natural, do witness'.[34] Natural philosophy is a 'speculative science', rather than a practical science. However, Sennert claims with Zabarella that it is 'superfluous to ad the term speculative, seeing if we take the word Science properly, all Sciences are

[33] Sennert 1618, pp. 12–15; trans. Sennert 1660, pp. 5–6.
[34] Sennert 1618, p. 17; Sennert 1660, p. 6.

speculative' (Sennert 1618, p. 10; Sennert 1660, p. 7).[35] Ethics, oeconomy, and politics are sciences only in a broad sense of the term.[36]

A comparison of Toletus' and Sennert's views shows that, even among the adopters of the Aristotelian divisions, there was some degree of variety. However, there is one claim on which nearly all authors who distinguished between speculative and practical philosophy before Bacon agreed. This was the claim that natural philosophy was a *speculative*, theoretical, or contemplative discipline, rather than a practical, operative, or productive discipline.[37] Classifications of natural philosophy as a speculative, theoretical, or contemplative discipline could be found among Italian humanists[38] and Aristotelians,[39] Iberian Jesuits,[40] French scholastics,[41] German academics,[42] German and Dutch physicians,[43] and the authors of the manuals used and criticised by English experimental philosophers.[44] Even the post-Ramist Clemens Timpler, who disagreed with most of his contemporaries in regarding natural philosophy as an art, rather than a science, was quick to add that it was a speculative art, rather than a practical or a productive art.[45]

1.3 From *Scientia Experimentalis* to *Archemastrie*

There were, however, in the Middle Ages and the Renaissance, other approaches to the study of nature that were not purely speculative, and these, to some extent, anticipated the experimental natural philosophy developed in the early Royal Society.

[35] See Zabarella 1597, col. 3.

[36] For a similar scheme that omits politics, see Deusing 1644, p. 21.

[37] Reif 1969, p. 20, notes that this was typical for natural philosophy textbooks published between 1600 and 1650. It was also common in works of logic. See, for example, Blundeville 1617, p. 163. At least one author before Bacon claimed that there was a non-theoretical, practical part of physics: namely, Johann Grün, a Protestant theologian in sixteenth-century Wittenberg. He included the following disciplines within practical physics: medicine, practical parts of mathematics, practical arithmetic, practical music, optics, astronomy, geodesy, and mechanics. See Grün 1587, pp. 80–100.

[38] Poliziano 1553, p. 462.

[39] Zabarella 1597, col. 2.

[40] Conimbricenses 1616, cols. 26–31. Toletus, whom we discussed previously, was from Spain.

[41] Eustachius a Sancto Paolo 1614, 1, p. 2; Pierre de Saint-Joseph 1659.

[42] Keckermann 1606, pp. 1–3; Alsted 1630, 1, p. 3.

[43] See the previous discussion of Sennert and note 36 on Deusing.

[44] Magirus 1619, pp. 5–6; Scheibler 1639, p. 4; Burgersdijck 1631, p. 3. Newton 'was introduced to Aristotelian physics' via Magirus' textbook (Westfall 1980, p. 84). Locke criticised Scheibler and Burgesdijck in his 1989 [1693] work, p. 157. For other mentions of Burgersdijck, Magirus, and Scheibler in Locke's writings, see Milton 1984.

[45] Timpler 1613, 1, pp. 5–6.

For example, the thirteenth-century philosopher Roger Bacon promoted a practical method for the acquisition of knowledge of the natural world that combined the use of mathematics and detailed descriptions of natural phenomena. Bacon singled out a new discipline that was supposed to apply this method. He called it *experiential science* (*scientia experimentalis*), distinguishing it from the more speculative discipline of natural philosophy. According to Bacon, experiential science has three aims. First, it should provide mathematical descriptions of natural phenomena based on empirical evidence, rather than demonstrative reasonings from principles. Second, it should discover instruments, medical cures, and military technologies, and it should make chemical discoveries. Third, it should prognosticate 'the future on the basis of astronomical/astrological knowledge' (Hackett 2020, §5.4.3).

Experiential science, therefore, has practical purposes, and it relies on observations and experiments. Nevertheless, Roger Bacon did not advocate a systematic and extensive use of controlled experiments, nor did he put forward a theory, methodology, or philosophy of experiment.[46] It is telling that 'for his description of the first example of an experimental science, the study of the rainbow, Bacon depends on the accounts handed down by Aristotle, Seneca, and Avicenna', although 'he is not uncritical of these accounts' (Hackett 2020, §5.4.3). Hence, we should not overestimate the degree to which Roger Bacon's experiential science anticipates either experimental science as we currently understand it or the experimental natural philosophy advocated by Robert Boyle and the members of the early Royal Society.

It is unlikely that many first-generation experimental philosophers read Roger Bacon's texts, given their predilection for works written in the late sixteenth and seventeenth centuries.[47] However, a text that was widely read in late sixteenth- and seventeenth-century England took inspiration from Roger Bacon's *scientia experimentalis* to advocate the introduction of an operative, non-speculative form of natural philosophy. This was John Dee's 'Mathematicall Praeface' to the English translation of Euclid's *Elements*, first published in 1570. At the end of his classification of mathematical disciplines, Dee introduces the new discipline of Archemastrie which

> teacheth to bryng to actuall experience sensible, all worthy conclusions by all the Artes Mathematicall purposed, & by true Naturall Philosophie concluded: & both addeth to them a farder scope, in the termes of the same Artes, & also by hys propre Method, and in peculier termes,

[46] This also applies to Robert Grosseteste, *pace* Crombie 1953. On Roger Bacon and Grosseteste, see Hackett 1994.

[47] For Locke's reading, see Milton 1984, pp. 30–1. For Boyle's reading, see Hunter, Avramov, and Yoshimoto 2010. This also applies to Hobbes, whose knowledge of Aristotelianism largely relied on early modern sources. See Sgarbi 2001.

> procedeth, with helpe of the foresayd Artes [the mathematical arts], to the performance of complet Experiences, which of no particular Art, are hable (Formally) to be challenged. . . . *Science* I may call it, rather, then an Arte: for the excellency and Mastershyp it hath, over so many, and so mighty Artes and Sciences. And bycause it procedeth by *Experiences*, and searcheth forth the causes of Conclusions, by *Experiences*: and also putteth the Conclusions them selves, in *Experience*, it is named of some, *Scientia Experimentalis*. The *Experimentall Science*. *Nicolaus Cusanus* termeth it so, in hys *Experimentes Statikall*, And an other Philosopher, of this land Native [Roger Bacon] . . . The Arte carrieth with it, a wonderfull Credit: By reason, it certifieth, sensibly, fully, and completely to the utmost power of Nature, and Arte. This Arte, certifieth by *Experience* complete and absolute: and other Artes, with their Argumentes, and Demonstrations, persuade: and in wordes, prove very well their Conclusions. But wordes, and Argumentes, are no sensible certifying: nor the full and finall frute of Sciences practicable. (Dee 1570, sig. A.iij^{r-v})[48]

This passage is highly suggestive, not least because it contains one of the earliest occurrences of the expression 'experimental science' in English.[49] Nevertheless, one should not exaggerate the extent to which Dee's Archemastrie anticipates modern experimental science or early modern experimental philosophy. By deciphering Dee's cryptic references towards the end of the 'Mathematicall Praeface', Nicholas Clulee (1984) has established that Archemastrie combines the empirical verification of natural philosophical claims with magical practices such as divination by mirrors and reflecting surfaces.

What Archemastrie most clearly anticipates is Francis Bacon's operative natural philosophy, which is, we shall argue, a close antecedent of experimental natural philosophy. Like operative natural philosophy, Archemastrie does not replace traditional, speculative natural philosophy. It complements it by adding 'a farder scope'. Unlike traditional, speculative natural philosophy, Archemastrie does not rely on demonstrative reasoning: 'it procedeth by *Experiences*, and searcheth forth the causes of Conclusions, by *Experiences*: and also putteth the Conclusions them selves, in *Experience*'. It is an 'Experimentall Science' in the broad, early modern sense of the term 'experimental', best rendered in current language as 'experiential': that is, it relies on observations and experiments. Insofar as it 'procedeth . . . to the performance of complet Experiences', including observations, experiments, and magical practices, Archemastrie is an operative discipline. This induces Dee to call it an art, although it could also be called a science for 'its excellency and Mastershyp'. Archemastrie sits uneasily between the realms of art and science,

[48] On Dee's reference to Cusanus, see Nagel 2005.

[49] According to Nagel (2005, p. 106), this is the first occurrence of 'experimental science' in English.

unlike Francis Bacon's operative philosophy, which he firmly places within the domain of natural philosophy. In order to understand Francis Bacon's reasons for introducing an operative, non-speculative component of natural philosophy, we need to turn to the disciplinary status of two disciplines: natural magic and mechanics.

1.4 New Developments: Magic and Mechanics

Typically, early modern classifications of the disciplines did not include any form of magic within the realm of natural science. This was not because of a widespread scepticism about magic. The same authors who denied the status of natural science to magic often defended natural magic as a perfectly respectable activity. Natural magic, as distinct from demonic, or black, magic, aimed to bring about effects that may seem preternatural by exploiting the hidden natural powers of things.[50] Given its practical purposes, natural magic could not be part of a purely theoretical science like natural philosophy.[51]

Many practitioners and advocates of natural magic thought otherwise. They regarded it as 'the pinnacle of natural philosophy and its most complete achievement', as Agrippa wrote in 1533.[52] If natural magic was a part of natural philosophy, then it was a science. Fifty years after Agrippa, Giambattista della Porta wrote about magic: 'They that have been most skilful in dark and hidden points of learning, do call this knowledge the very highest point, and the perfection of natural Sciences.'[53]

Magical texts included highly theoretical treatments of the so-called *scientia* of magic, like that of Ficino, but they also included purely technical manuals and collections of recipes. Della Porta brought out this practical aspect of magic by alluding to a famous statement by Pico della Mirandola: 'Others have named it the practical part of natural philosophy, which produces her effects by the mutual and fit application of one natural thing unto another' (della Porta 1589, p. 2 = della Porta 1658, p. 2).[54] Like other practitioners, della Porta aimed to integrate the theoretical and practical aspects of natural magic. His *Twenty Books of Natural Magic* combined an exposition of Ficino's theory of magic

[50] See Henry 2002, p. 55; Eamon 1994, p. 194.

[51] See, for example, Conimbricenses 1616, col. 21.

[52] Agrippa 1533, p. ccclii, echoing Pico della Mirandola 1965 [1486], p. 26.

[53] Della Porta 1589, p. 2 = della Porta 1658, p. 2. See Pico della Mirandola 1998 [1486], thesis 11.9.9: 'there is no department of knowledge [*scientia*] that gives us more certainty of Christ's divinity than magic and cabala'. This claim is echoed in Russiliano Sesto 1991 [1519], cited in B. Copenhaver 1988, p. 273. The most famous medieval book of natural magic, a collection of recipes widely read in the early modern age, calls magic 'Scientia magicalis' (Pseudo-Albertus Magnus 1483, sig. a ii, trans. as Pseudo-Albertus Magnus 1974, p. 3).

[54] See Pico della Mirandola 1998 [1486], thesis ii.9.3.

with a collection of techniques and recipes.[55] Della Porta would have agreed with Tommaso Campanella's description of natural magic as a 'speculative and at the same time practical' form of wisdom (Campanella 1620, p. 153).

Francis Bacon was highly critical of his predecessors' magical practices, yet he agreed with della Porta and Campanella in regarding natural magic as a science and a part of natural philosophy, but also as a practical or operative discipline. These two features are apparent in Bacon's definition of magic as 'the science [*scientia*] which applies the knowledge of hidden forms to the production of wonderful operations' (*De augmentis scientiarum*, in SEH 4 366–7). Regarding natural magic as a branch of natural philosophy, while acknowledging its operative character, meant introducing an operative, non-speculative part of natural philosophy, as Bacon did as early as 1605 in *The Advancement of Learning*.[56]

The disciplinary shifts that led to the genesis of operative natural philosophy did not only concern natural magic. They also concerned what was sometimes called 'mathematical magic', that is, mechanics.[57] In the Renaissance, mechanics was typically classified as an art, not as a science (or more precisely, as a *scientia*). This classification was accepted by Toletus, who, as we have seen, called the productive arts *mechanica*, and also by Leonico Tomeo, the humanist scholar who published an early Latin translation of the pseudo-Aristotelian *Mechanical Problems* (*Quaestiones mechanicae*) in 1525.[58] This classification would be challenged fifty years later, when the Paduan philosopher Niccolò Piccolomini published a widely read paraphrase of the *Mechanical Problems*. Piccolomini no longer regarded mechanics as an art, but as a *scientia*. Like another Paduan Aristotelian, Giuseppe Moletti, Piccolomini classed mechanics as a part of speculative philosophy, more precisely of mathematics.[59] He did not regard it as a part of natural philosophy because the latter concerns natural motions, whereas mechanics concerns unnatural, violent motions.[60] However, mechanics was typically concerned with ways of *effecting* unnatural motions for practical purposes. The Aristotelians acknowledged that being 'directed towards human ends'

[55] This is noted in B. Copenhaver 1998, p. 455.

[56] *The Advancement of Learning*, OFB 4 88. See also *Novum organum*, in OFB 11 215 and *De augmentis scientiarum*, SEH 4 365. For further discussion, see Anstey 2012, pp. 22–6.

[57] For an example of this expression, see Wilkins' *Mathematicall Magick*, Wilkins 1648. On the link between mathematical magic and the new mechanical philosophy, see Grafton 2005. For mechanics and wonder, see Young 2017a.

[58] *Aristotelis Quaestiones mechanicae*, in Tomeo 1525. On Tomeo's classification, we rely on Laird 1986, p. 49, and Hattab 2005, p. 105.

[59] Moletti's classifications in a manuscript from the 1580s are summarised in Laird 1986, pp. 61–2. Against the classification of mechanics as a part of philosophy, see Sennert's comment cited in Section 1.1.

[60] See Piccolomini 1565. Piccolomini's classifications are summarised in Laird 1986, pp. 50–1, and Hattab 2005, p. 108.

was 'the chief characteristic of mechanics' (Laird 1986, p. 68). Therefore, mechanics sat uneasily within the realm of the speculative sciences.

Given the practical purpose of mechanics, it should not be surprising that Francesco Maurolico (or Maurolyco), one of the leading mathematicians of the sixteenth century, classed mechanics, together with ethics, as a part of *practical* philosophy.[61] By contrast, he classed physics – that is, natural philosophy – and mathematics as parts of speculative philosophy. Yet mechanics was closely associated with those disciplines. It was often regarded as a mixed discipline, deriving from the combination of mathematics with physics. For instance, Maurolico regarded all mechanical theory (*ratio*) as intermediate between mathematics and mechanics.[62] For Niccolò Tartaglia, another eminent writer on mechanics, the *whole* of mechanics derived in part from mathematics and in part from natural philosophy.[63]

Attempts to classify mechanics appear to have reached an impasse. On the one hand, its classification as a speculative science was at odds with its practical orientation. On the other hand, its classification as a practical science did little justice to its intimate connection with the allegedly speculative sciences of mathematics and natural philosophy. Francis Bacon's classification of natural philosophy provides an interesting resolution to this problem. Rejecting the scholastic distinction between natural and violent motions, he classified mechanics as an operative science, which was correlated to physics on the speculative side of natural philosophy. He grouped mechanics with magic, which itself was correlated to speculative metaphysics.[64]

Thus, Bacon's schema has a robust operative, that is, non-speculative, side to natural philosophy. Furthermore, Bacon also identified a form of mechanics that he regarded as a constituent of natural history.[65] This grafting of mechanics to the operative side of natural philosophy and the intimate connection between mechanics and natural history provided an important precedent for the inclusion of mechanics as a part of experimental philosophy later in the century. It reflected the conviction of a growing number of intellectuals that the technical subjects are highly relevant to natural philosophy. The Spanish humanist Juan Luis Vives, while a tutor at the English court, had exhorted scholars to pay attention to the technical problems regarding the construction of machines, agriculture, weaving, and navigation as early as 1531 (Vives 1531). Georgius Agricola's widely read *De re metallica* (*Of Metals*), published in Basel in 1556, 'clearly illustrated the relevance

[61] Maurolico's (1613) classification is reproduced in Hattab 2005, p. 111. Maurolico's work was composed around 1569 and published posthumously.

[62] Laird 1986, p. 54. Another important author, Bernardino Baldi, held that the theory of mechanics derives from the combination of mathematics with physical principles (Laird 1986, p. 57).

[63] Tartaglia 1546, p. 81, trans. in Drake and Drabkin 1969, p. 111.

[64] *De augmentis scientiarum*, SEH 4 365.

[65] SEH 4 365–6. See also *Parasceve*, in OFB 11 461.

of craft knowledge to an understanding of the nature of the world' (Henry 2002, p. 34). Around 1562, Sir Humphrey Gilbert linked natural philosophy to the teaching of technical subjects in his plan for Queen Elizabeth's Academy.[66] Then in 1600, William Gilbert availed himself of works published by craftsmen in his *De magnete* (*On the Magnet*), where he combined a natural philosophical discussion of magnetism with technical discussions of problems of navigation, natural instruments, techniques for fusing metals, and problems of mining engineering.[67] At the same time, a mechanicist philosophy of nature was emerging, in which living beings and the whole world are machines operating according to mechanical regularities.[68] This implies that those 'laws' apply to natural and unnatural motions and, hence, are objects of study of natural philosophy. Many experimental philosophers would embrace this view. It provided an even stronger underpinning for the inclusion of the non-speculative, operative discipline of mechanics within natural philosophy than Bacon had offered.

Francis Bacon's mature schema for philosophy is found in his *De augmentis scientiarum* of 1623. Bacon's basic tripartite division of knowledge is into history, poesy, and philosophy. These divisions correspond, for Bacon, to the three intellectual faculties of memory, imagination, and reason. He divides the third branch of knowledge, philosophy, into three: of the deity, of nature, and of man.[69] Philosophy of nature, as we have seen, is divided into speculative and operative (Figure 1.5). Speculative philosophy is divided into metaphysics and physics. Operative philosophy is divided into mechanics and magic.

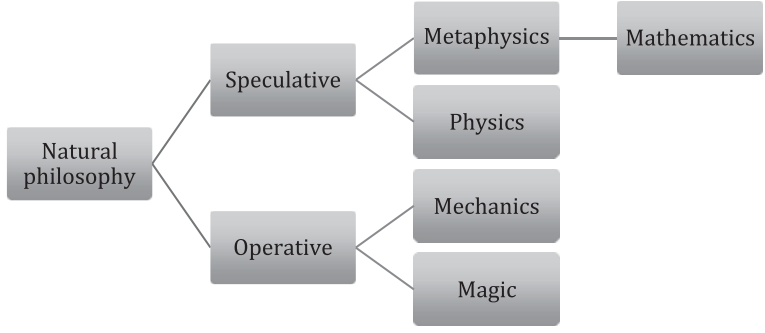


Figure 1.5 Francis Bacon's mature division of natural philosophy

[66] See Rossi 1970, pp. 9–10.
[67] This is noted in Rossi 1970, pp. 40–1.
[68] In Italy, Giuseppe Moletti claimed that 'nature uses mechanics in its own works' in lectures from the 1580s. In France, Henri de Monantheuil claimed that the whole world is a machine in 1599. See de Monantheuil 1599, p. 3; Laird 2008, pp. 173, 183; Hattab 2005.
[69] *De augmentis scientiarum*, SEH 4 336.

Bacon's operative/speculative distinction contains one very important development on that of Toletus: it pertains to *natural philosophy* and not to philosophy in general. A further, minor, difference is that Bacon regards mathematics as a branch of metaphysics rather than as a part of speculative philosophy in its own right. Moreover, it is worth pointing out, given developments later in the century, that for Bacon natural history is one of three parts of history, but its content overlaps with physic in speculative philosophy and with mechanic in operative philosophy. For Bacon, natural history and natural philosophy are, therefore, not discrete disciplines.[70]

The profound influence of Bacon's reconfiguring of natural philosophy is nicely illustrated in the work of John Johnston. Johnston was a natural historian who spent much of his adult life on the Continent and published in Latin. His work has generally escaped notice amongst historians of English science,[71] but he studied in St Andrews and Cambridge and seems to represent a fairly independent voice concerning developments in natural philosophy in the period before the establishment of the Royal Society. Johnston's two natural histories, shaped by his millenarian pedagogical ideals, occupy an intermediate position 'between the works of his humanist predecessors and those of his more resolutely empirical successors' (Miller 2008, p. 233). He adopts a conventional twofold division of philosophy in his *Naturæ constantia* (*The Constancy of Nature*) of 1634, translated into English in 1657: 'But Philosophie being either speculative, or practicall, and that [which] we speak of in this part [i.e., speculative philosophy] comprehends under it, *Metaphysicks*, *Physickes*, and *Mathematickes*' (Johnston 1657, p. 82 (= Johnston 1634, p. 68)). As one might expect, in his discussion of metaphysics he refers to a gallery of scholastics: Averroes, Thomas, Scotus, Sánchez, Suárez, Fonseca, and Masius.

We note here, however, one absolutely crucial development (Figure 1.6). This is the claim that 'the practick part of Philosophy was, till now, in the greatest darknesse; at last in our age the way to it was opened by famons [*sic*] *Verulam . . . in his New Organum*, his Sylva Silvarum, his Historie of Life and Death, and of Windes' (Johnston 1657, p. 84 (= Johnston 1634, p. 69).[72] From the wider context it is clear that Johnston is referring to the practical part of natural philosophy.

Johnston's picture of natural philosophy is then a transitional one. It begins looking just like that of Sennert, with the standard divisions and with reference to scholastic masters' treatment of metaphysics. But when he discusses the advances in natural philosophy, he regards Bacon's *Novum organum* and exemplar natural

[70] See Anstey 2012.

[71] The best recent treatment of Johnston's natural historical writings is Miller 2008.

[72] *Pace* William B. Ashworth who claims that with respect to natural history 'Johnston was not touched by Bacon at all' (1990, p. 324).

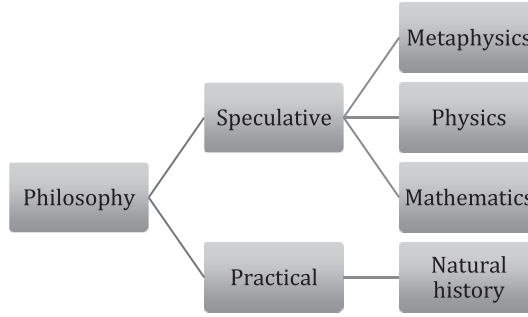


Figure 1.6 Johnston's division of philosophy with natural history

histories as being representative instances of the practical part of natural philosophy, even though natural philosophy is classified as a speculative science.

1.5 Conclusion

It is now time to draw some conclusions from the foregoing discussion. First, it is clear that there are some salient discontinuities between the ESD in the early modern period and the practical/speculative distinction that derived ultimately from Aristotle. From the 1660s, the ESD is an all-encompassing division pertaining to *natural philosophy*. By contrast, the speculative/operative distinction, from Aquinas through Toletus to Johnston, pertains to *philosophy in general*, and not to natural philosophy in particular. The main exception to this obvious discontinuity is the position of Francis Bacon, who restricts the speculative/operative distinction to natural philosophy. It may be that this fundamental Baconian shift was an important factor in the emergence of the ESD in England in the 1660s. Whatever the case, this shift of domain of application from philosophy to natural philosophy represents a crucial development.

Ironically, however, by the mid-eighteenth century, the ESD was applied to philosophy in general, though this was not a return to the old operative/speculative distinction deriving from Aristotle; rather it stemmed from a desire to apply the prevailing method of natural philosophy to other branches of philosophy. For example, as we shall see in Chapter 6, attempts to apply the method of experimental philosophy were commonplace in Scottish moral philosophy.[73]

A second, related discontinuity is that natural philosophy changed from being a speculative science to being *either* speculative *or* operative (i.e., experimental) science. To be sure, this transition occurred over a number of generations as a result, *inter alia*, of the re-evaluation of the status of mechanics and magic and the role of experiment. But by the mid-seventeenth century, the

[73] See, for example, Turnbull 1740b, epistle dedicatory, p. i; preface, pp. i–iii.

broader conception of natural philosophy adumbrated by Francis Bacon and others had become the dominant view.

In spite of this, remnants of the Renaissance view persisted well into the early modern period. For example, Gideon Harvey classified natural philosophy as a speculative science in his *Archelogia Philosophica Nova, or New Principles of Philosophy* of 1663,[74] and we can see the persistence of the scholastic distinction between speculative and practical principles in John Locke's early *Essays on the Law of Nature* of *c.* 1664.

> If the law of nature were written in our hearts, it would have to be inferred that speculative as well as practical principles are inscribed. But this seems difficult to prove; for if we try to search out the first and best known principle of the sciences (namely, that it is impossible that the same thing should at the same time both be and not be), it will be readily agreed that this principle is not inscribed by nature as an axiom in our hearts nor taken for granted by anyone before he has either learned it from another or (which is the proper method of establishing principles) proved it to himself by induction and by observing particulars. Thus it appears to me that no principles, either practical or speculative, are written in the minds of men by nature. (Locke 1954, p. 145).

Of course, this is the kernel of Book One of Locke's *Essay concerning Human Understanding* (1690) in which he dismisses innate speculative and practical principles.

A third point of discontinuity is that the scholastic faculty psychology, which underpinned the distinction between speculative and practical knowledge and principles, drops out of the picture. Given that the ESD emerged as a way of demarcating approaches to the practice of natural philosophy, it is hardly surprising that faculty psychology is virtually absent in the writings of the early Fellows of the Royal Society and those promoters of experimental philosophy within its ambit. Few, if any, natural philosophers had time for the theory of the speculative and practical intellect, for they were concerned rather with the method of acquiring knowledge of nature through experiment and observation.[75] This is not true, however, of religious discourse, where the terms remained in use well into the seventeenth century. Take, for example, the divine Richard Baxter, who mentions the practical intellect in both his *Saints' Everlasting Rest* (1654) and his *Catholick Theologie: Plain, Pure, Peaceable* (1675).[76]

Another absolutely decisive difference between the ESD and the traditional operative/speculative distinction is the fact that the content of the operative

[74] G. Harvey 1663, pp. 14–15.

[75] In the 'Preliminary Discourse' to the *Encyclopédie*, d'Alembert does deploy Bacon's three intellectual faculties – memory, reason, and imagination – as a partial justification for following the Baconian division of knowledge into history, philosophy, and poesy. See PD, pp. 50–5, 143.

[76] See Baxter 1654, p. 230 and 1675, p. 153. See also South 1663, pp. 14–15 and Hale 1677, p. 47.

side is completely redefined. From the time of Aristotle, the operative part of philosophy had always included ethics, politics, and oeconomy, or some variant. As we have seen, however, in the work of Francis Bacon, the operative branch of natural philosophy includes mechanics and magic. Moreover, as we have also seen, in the *De augmentis scientiarum* Bacon claims that 'there is also a kind of Mechanic often merely empirical and operative, which does not depend on Physic; but this I have remitted to Natural History, taking it away from Natural Philosophy' (SEH 4 365–6).

While a full exposition of Bacon's view is not possible here, it is important to point out that, for Bacon, natural history has three subjects, namely, generations, pretergenerations (monsters), and arts or mechanic. What he claims in the *De augmentis scientiarum* is that one aspect of the operative part of natural philosophy belongs to natural history. In other words, Bacon identifies a type of mechanics in the operative branch of natural philosophy with mechanics or arts in natural history.[77]

Proceeding chronologically, it is natural to view the schema of John Johnston as providing a transitional view insofar as he speaks of the operative part of philosophy in terms of Bacon's natural histories. And by the time that the ESD emerged in the 1660s, the operative part had come to be entirely characterised in terms of observation and experiment. This brings us to another important development: operative, or practical, philosophy becomes experimental.

At some point in the decades between the death of Bacon and the founding of the Royal Society, natural philosophers in England ceased to speak of the operative, or practical, part of philosophy and began to speak of experimental philosophy. This is explicitly acknowledged by Henry Oldenburg, the first Secretary of the Royal Society, who gives a very interesting potted history of the emergence of the experimental philosophy:

> In the last Age, when *Operative Philosophy* began to recover ground, and to tread on the heels of triumphant *Philology*; emergent adventures and great success were encountred by dangerous oppositions and strong obstructions: *Galilaeus* and others in Italy suffered extremities for their Celestial Discoveries; and here in England Sr. *Walter Raleigh*, when he was in his greatest luster, was notoriously slaundered, to have erected a School of Atheism, because he gave contenance to Chymistry, to practical Arts, and to curious Mechanical Operations, and design'd to form the best of them into a Colledge, And Queen Elizabeths *Gilbert* was a long time esteem'd extravagant for his Magnetismes; and *Harvey* for his diligent researches in pursuance of the Circulation of the Blood.
>
> But, when our renowned Lord *Bacon* had demonstrated the Methods for a perfect Restauration of all parts of Real knowledge; and the Generous

[77] For a detailed discussion, see Anstey 2012.

> and Philosophical *Peyreskius* had, soon after, agitated in all parts to redeem the most instructive Antiquities, and to excite Experimental Essays, and fresh Discoveries; The success became on a sudden stupendious, and Effective philosophy began to sparkle, and even to flow into beams of bright-shining Light, all over the World.
>
> (Oldenburg 1672, pp. 4001–2)[78]

Oldenburg's potted history tells us whom he regarded as seminal contributors to the emergence of experimental philosophy, but it does not give us any inkling into the emergence of the expression 'experimental philosophy'. Unlike *scientia experimentalis*, which was used all over Europe,[79] 'experimental philosophy' became a common English expression only from the early 1660s; by the late 1660s, it appeared in Italian and in the 1670s in French.[80] We mentioned in the Introduction that the earliest known use of that expression in English is in Samuel Hartlib's private *Ephemerides* in 1634, just eight years after Bacon's death.[81] On the Continent, Athanasius Kircher used the Latin expression *philosophia experimentalis* in 1641 in the preface of his second book on magnetism, one of the most important and widely read books on this topic after Gilbert's *De magnete*.[82] Five years later, as we have seen, Niccolò Cabeo used the same expression in the extended title of his commentary on Aristotle's *Meteorology*. Importantly, Cabeo's commentary was cited twice in Robert Boyle's *Spring of the Air* (1660), which is only the second printed work in English to use the expression 'experimental philosophy'.[83] In the 1680s, the editors of Cabeo's and Kircher's works featured the expression 'experimental philosophy' in the titles of those works, as did other Continental authors.[84] They were trying to exploit what had by then become a popular brand.

Interestingly, Peter Harrison has shown that by the time Hartlib, Cabeo, and Kircher started using the expression 'experimental philosophy', the term 'experimental' in contrast to 'speculative', was already in common use in

[78] Mihnea Dobre alerted us to this reference.

[79] Dee in England, Gassendi in France, Campanella in Italy, Calvin in Switzerland, and the royal physician of the Spanish kings all used the expression *scientia experimentalis* in the sixteenth or early seventeenth century. See Gassendi 1658 (composed between 1620 and 1624), p. 207; Campanella 1622, p. 15 = Campanella 1994, p. 57; Calvin 1890 [1559], vol. 44, col. 162; Ponce de Santa Cruz 1624, p. 3. On John Dee, see Section 1.2 above.

[80] See Montanari 1667, p. 6; du Hamel 1672, *passim*; Bartoli 1677, pp. 305–6.

[81] See Hartlib Papers, 29/2/11A.

[82] Kircher 1641, Prooemium ad lectorem, sig. a8^{v}.

[83] Boyle, *Spring of the Air* in B 1 143, 158, and 207. Citations from Cabeo's commentary are on pp. 258, 271. The term 'Experimentall Philosophie' occurs in the anonymous preface to Boyle's *Seraphic Love* (1659), B 1 60–1; see Section 2.1 below.

[84] Kircher 1680; Denstonius 1682; Cabeo 1686.

religious literature. For example, in 1606 Arthur Dent compared the reprobate with the elect in the following terms:

> The knowledge of the reprobate doth puffe up.
> The knowledge of the elect doth humble.
> . . .
> The knowledge of the elect is spirituall, and experimentall.
> The knowledge of the reprobate is speculative.
>
> (Dent 1606, sig. ℭb 4–5)[85]

More work needs to be done on these very interesting semantic developments,[86] but what is clear is that the experimental terminology was not the exclusive domain of natural philosophers and that there were multiple sources from which the terminology of the new approach to natural philosophy could have drawn. No doubt as the experimental work of Galileo, Torricelli, Harvey, and others became well known, the importance of experiment in the acquisition of knowledge of nature emerged as the prominent feature of the practice of the new philosophy. A case in point is Francis Bacon, in whose later writings we find a nascent philosophy of experiment, which was to influence some of the leading natural philosophers of the early Royal Society.

Last, but not least, is the development of an antagonism between experimental and speculative philosophy. In England, there was a precedent for this in Francis Bacon's warnings against the ill-informed development of theories, his idols of the theatre, and natural philosophical speculations that lacked adequate observations and experiments.[87] On the Continent, the antagonism between experiment and speculation could be found in the medical debates that unfolded in the Netherlands between the 1640s and the 1660s and debates over the appearance of two new comets in France in 1664–5. Physicians like Cornelis van Hogelande and Franciscus de le Boë Sylvius contrasted the speculative conclusions of the Cartesians, derived by way of reasoning (*ratiocinatio*) from mechanistic principles, with Harvey's 'real and sensual disquisitions' (*disquisitiones reales & sensuales*), that is, experiments and observations.[88] And some Montmorians criticised Descartes' theory of comets for its lack of appeal to observations.[89] On the whole, however, such antagonism is not a characteristic of the scholastic treatments of operative and

[85] Quoted in Harrison 2011. See also Pumfrey, Rayson, and Mariani 2012.
[86] For a study of the emergence of the term 'experiment', see Dear 2006.
[87] *Novum organum*, OFB 11 97–107. For Bacon's influence, see, for example, Austen 1658, sig. A3^{r}.
[88] Van Hogelande 1646, pp. 195–6; see Sylvius, disputation *De Febribus Prima*, held in Leiden in 1661, props. 19–20, in Sylvius 1681, p. 26. Evan Ragland alerted us to these references.
[89] See Roux 2017, pp. 119–26. Roux stresses that there were many other facets to the debate over these comets (p. 129).

speculative philosophy. By contrast, as we shall see in the next chapter, from the 1660s there is an almost monotonous call to avoid the hypotheses and 'castles in the air' of the speculative philosophers. Again and again, the methodological writings of the new philosophers pit experimental philosophy against its speculative counterpart. To be sure, some like Boyle argued for the mutual assistance that both might render each other.[90] But the majority of writers were more inclined to highlight the opposition of experiment to speculation and to warn their readers off the latter. This manifested itself in strong anti-hypothetical rhetoric, most famously in Newton, and in attacks on maxims and hypotheses as found in Locke's *Essay* (IV. vii, xii). Thomas Molyneux, in his natural history of coughs, assures his readers 'I shall therefore confine my self in the following History as close as I can to strict Matter of Fact, passing by all Hypotheses' (T. Molyneux 1694, p. 105). Similar sentiments can be found in writings right up to the end of the eighteenth century, and they were not restricted to natural philosophy and medicine. Thus, the poet and physician Sir Richard Blackmore could write in the Preface to his poem 'King Arthur', 'The raising of an Hypotheses in Philosophy obtains little more Credit with me, than the erecting a Scheme in Astrology, and the Judgments and Decisions that are given upon them seem to me alike Precarious and uncertain' (Blackmore 1697, p. ix). And as late as 1773, the German Jesuit philosopher Jacob Zallinger looked back at Newton's legacy and claimed: 'Having rejected hypotheses and arbitrary notions and having left aside that anxious desire to fabricate systems . . . famous men took on the task of interpreting nature by contemplating its works and, as it were, listening to its voice. And this is that very method, which is named the NEWTONIAN' (Zallinger 1773, sig. 3v).[91]

From the foregoing survey, it is clear that the ESD is in many ways discontinuous with the common divisions of knowledge and, in particular, the place of natural philosophy within those divisions in late Renaissance writings. Furthermore, in spite of its obvious debt to Francis Bacon, it is discontinuous in many respects with his conception of the nature and classification of natural philosophy. And yet, it is also apparent that the operative/speculative distinction, deriving ultimately from Aristotle, provided the fundamental dichotomy from which the later distinction derived. The evidence assembled here indicates that it neither appeared *de novo* in the middle of the seventeenth century nor was strictly continuous with any distinction that preceded it.

[90] See Anstey and Hunter 2008, pp. 97–9, for references and discussion.
[91] Translation from Ahnert 2004, p. 488.

CHAPTER 2

Experimental Philosophy in the Seventeenth Century

Experimental philosophy was a new, distinctive form of natural philosophy when it emerged in the late 1650s in England. In this chapter, we trace its development from its humble beginnings among the Oxford 'Philosophical club' and the nascent Royal Society to its pre-eminence in British natural philosophy by the end of the seventeenth century and its gradual spread to the Continent from the 1660s. We also explore its relations with medicine and religion, as well as its opponents and polemical targets.

2.1 The Emergence of Experimental Philosophy

As we have shown in the Introduction, the term 'experimental philosophy' had been in use since the 1630s. Moreover, there were many who were using and recommending the use of experiments in the decades leading up to the emergence of experimental philosophy. Yet it was in the work and writings of the Oxford-based 'Experimentall Philosophy club', a precursor group to the Royal Society of London, that this new, distinctive form of natural philosophy first began to take shape.[1] It is not possible to reconstruct from the historical record the precise process or to name all of the people involved, but we have enough evidence from descriptions of their activities and methodology to pinpoint its period of gestation and to claim confidently when and where experimental philosophy was born.

It has long been known that the Oxford club provided the nucleus of the founding Fellows of the Royal Society and that this group was convened by John Wilkins, Warden of Wadham College. What has been less remarked upon is that it is the activities and writings of this group that provide the first really determinate referent for the term 'experimental philosophy' and that the methodological reflections of its members, writings that were contemporaneous with its activities, contain the central tenets of the movement of

[1] Of course, experiments were performed in centres other than Oxford in the 1650s. For Petty's experiments on magnetism in London, see Pepys to General Montagu, 11 December 1656, Pepys 1933, p. 4. For Christopher Wren and Timothy Clarke's experiments in London on blood transfusion in 1657, which were closely tied to activities in Oxford, see Frank 1980, p. 172.

experimental philosophy. In short, the Oxford philosophical club, in the latter years of the 1650s, was the site of the gestation of experimental philosophy.

The primary seam of evidence centres on Robert Boyle and John Wilkins, and we will pick up the trace in early 1657. First, however, we need to digress to Italy in the 1640s.

When back in 1644 Evangelista Torricelli had his disciple Vincenzo Viviani insert a long glass tube full of mercury, hermetically sealed at one end, into a bowl of mercury, he noted two things. First, the column of mercury only partially descended into the bowl and was somehow suspended in the tube, and second, there was an apparent empty space above the suspended mercury column.[2] Two questions presented themselves: What holds the mercury column up? And what is the status of the space in the tube above the column? Blaise Pascal was convinced that it was the pressure of the air that held the mercury up and postulated that, if there were less pressure in the air at greater elevations, this could create a variation in the height of the mercury column. He established this with a very famous experiment carried out by his brother-in-law on the Puy de Dôme in 1648.

Boyle, for his part, had been interested in the nature of air and, in particular, the phenomena of the Torricellian apparatus from the early 1650s,[3] but he appears to have begun his experiments on the phenomena in early 1657, and the bulk of them were performed two years later once his famous air pump had been constructed. Boyle realised that, if he could manipulate the air surrounding the Torricellian apparatus, he might be able to gain a deeper understanding of both the quality of the air that held the mercury up and the status of the space at the top of the tube. He had Hooke construct an air pump that enabled one to extract the air from a large glass receiver into which one could insert a Torricellian apparatus. Using a rack and pinion device, air was extracted from the vessel, and a partial vacuum was created. As the air was extracted, Boyle noted that the mercury suspended in the tube began to fall. When he readmitted the air, it rose again. Boyle noticed further that there seemed to be a correlation between the amount of air extracted and the drop of the mercury column. It was suggested to him that this might be an inverse proportional relation, so he devised another set of experiments to test this claim. The result of these latter experiments, experiments that did not involve the air pump but rather a J-tube and long pipette, was the first articulation of Boyle's Law: that (at constant temperature) the pressure and volume of the air are in an inverse proportional relation. Boyle explained the suspension of the mercury column and the inverse relation that he had discovered by appealing to a new intermediate cause, namely, the spring of the air (what we now call pressure).

[2] See Middleton 1963.

[3] Boyle includes 'Additions to the Experiment De Vacuo' in a list of essays and experiments from *c.* 1654; B 14 330.

This series of experiments from Torricelli to Boyle has a number of salient features. First, each experimenter built upon the work and discoveries of their predecessors. Second, instruments and the creation of phenomena that do not naturally occur in nature played a central role. Third, Boyle's experiments allowed him (*a*) personally to experience (*b*) singular events, which happened at a specific time and place. The experience of these events was relied upon as (*c*) evidence for a general claim concerning the relation between pressure and volume of the air. This differs from traditional natural philosophers' references to experience, which were mostly (*a′*) based on common opinions, textual sources, or thought experiments about what happens (*b′*) not in specific circumstances, but always or for the most part, and which (*c′*) illustrated, rather than confirmed, general claims.

Interestingly, Boyle seems immediately to have seen the application of this notion of spring to a hitherto-unsolved problem in the physiology of animal respiration: Why do the lungs fill with air on expiration? Appealing to the air's spring, he established that the air did not force the lungs open by mechanical action, as Descartes had maintained. Nor was it drawn in by an attractive virtue in the lining of the lungs as the Galenists believed. Rather, the lungs filled with air because of the differential in pressure between the open lungs and the surrounding atmosphere.[4] This, the correct solution, was a clever piece of lateral thinking. To be sure, it drew on the anatomical knowledge that Boyle had earlier learnt from his Dorset neighbour Nathaniel Highmore and in Ireland from William Petty. And in all of this Boyle was ably assisted by Hooke. Yet the whole episode beautifully illustrates the extent to which Boyle was embedded in that group of natural philosophers and physicians in Oxford in the 1650s who have come to be called the Oxford physiologists and who were the primary conduit of Harvean experimentalism that fed into the fledgling movement of experimental philosophy that emerged in the 1660s.[5]

The experiments on the spring of the air, including a long digression on the problem of respiration, were quickly written up, and Boyle had his *New Experiments Physico-Mechanical, Touching the Spring of the Air and its Effects* ready for the printer in December 1659. The first print run of 500 copies had been completed by 26 January 1660.[6] In *Spring of the Air*, Boyle uses the term 'experimental philosophy' three times. It is striking that the first use appears in the second paragraph of the book, in the epistle 'To the Reader': 'in an Age so taken with Novelties as is ours, these new Experiments would be grateful to the Lovers of free and real Learning: So that I might at once comply

[4] For further discussion, see Frank 1980, pp. 142–4 and Anstey 2002, pp. 170–2.

[5] It is not clear to us why Levitin charges us with asserting 'that the Oxford physiologists were not "members" of the experimental philosophy movement' (Levitin 2019, p. 244). After all, Boyle and Hooke were both active participants in that loose cluster of physiologists, as documented by Robert Frank (1980).

[6] See Hunter's 'Introductory Notes' to *Spring of the Air*, B 1 cxxx–cxxxi.

with my grand Design of promoting Experimental and Useful Philosophy' (B 1 143). Here, in Boyle's first publication in natural philosophy, within two paragraphs, he has mentioned a new form of natural philosophy, emphasising its novelty and utility. His second reference to experimental philosophy is similar. It appears near the beginning of his dedicatory letter to his nephew, Charles Boyle. Boyle says his book may have served the 'Commonwealth of Learning' insofar as it 'may highly conduce to the advancement of that Experimental Philosophy, the effectual pursuit of which, requires as well a Purse as a Brain' (B 1 157–8). What Boyle is claiming is that his book is a work of experimental philosophy.

Then, in the description of Experiment 20, Boyle relates how some years before he had experimented to determine whether water had a property of spring similar to that of the air: 'About that time then, That Great and Learned Promoter of Experimental Philosophy Dr. *Wilkins*, doing me the Honor to come himself, and bring some of his inquisitive Friends to my Lodging, we there had in readiness . . . ' (B 1 207). This harmonises with the later recollection by John Aubrey about Wilkins as 'the principall Reviver of Experimental Philosophy' (Aubrey 2000, p. 342) and is augmented by John Wallis' claim that 'what was of this nature at *Oxford* (about Experimental Philosophy) in those days, was rather at Mr. *Boyl's* Lodgings, than at *Wadham*-Colledge' (Wallis 1678, p. 5). Wallis is referring to the months following September 1659 after Wilkins had left for Trinity College Cambridge, the precise time when Boyle was completing and writing up his experiments on the spring of the air. There is no doubt then that Boyle conceived of what he was doing in 1659 as experimental philosophy, and it was so remembered by his colleagues.[7]

Yet Boyle's writings and papers contain another layer beyond what is revealed in *Spring of the Air*. An anonymous preface to his *Seraphic Love* (which had appeared by September 1659 and was most likely penned by Boyle himself) mentions his 'Experimentall Essay's and other Physiologicall Writings' and 'how great a Lover he is of Experimentall Philosophy' (B 1 60–1). These physiological writings probably include his essays for a projected work begun in the mid-1650s and first taken to the press in January 1660.[8] They began to be printed in 1660 and finally appeared in 1663 under the title *Some*

[7] Mordechai Feingold (2016, pp. 7–8) has argued that later references to a pre-Restoration form of experimental philosophy by Wallis, Wood, and Aubrey are anachronistic. This claim is undermined, however, by Boyle's pre-1660 uses of 'experimental philosophy'. Boyle's use of the term provides corroborating evidence of the veracity of the later recollections of Wallis, Wood, and Aubrey. Wallis read Boyle's *Usefulness of Experimental Philosophy* soon after it appeared in 1663 and sent Boyle detailed notes on it. See *Boyle Corr.*, 2, pp. 112–17. See also M. Wren 1659, sig. A7^{v}; Sprat 1667, p. 56.

[8] Boyle tells us that he is holding back these essays until the return of his 'near Relation' (Richard Jones) to whom he subsequently dedicated *Usefulness of Experimental Philosophy*; see B 1 60.

Considerations touching the Usefulnesse of Experimental Naturall Philosophy, the first work of natural philosophy in English to use the term 'experimental philosophy' in its title. It concludes with an index that is, in effect, a summary of the contents and which begins: 'The reason why the Author endeavours to possesse *Pyrophilus* with the true value of *Experimental Philosophy* ' (B 3 286). Little wonder then that in the earlier *Spring of the Air* Boyle could call it 'Experimental and Useful Philosophy'.

The essays alluded to in the preface of Boyle's first book, *Seraphic Love*, also included the 'Some Treatises relating to Experimental Philosophy'[9] that comprised a third work on experimental philosophy, the constituents of which were circulating in Oxford in the mid-1650s.[10] They appeared in print in 1661, entitled *Certain Physiological Essays*. While *Spring of the Air* had been an *exemplar* of experimental philosophy and *Usefulness* was to be a work on the *rationale* of experimental philosophy, *Certain Physiological Essays* contained a significant amount of material on the *methodology* of Boyle's experimental philosophy. This includes the very important 'Proëmial Essay' that contains the central tenets of what was soon to become the experimental philosophy movement.

We will turn to the contents of the 'Proëmial Essay' below, but here it is worth reiterating that the term 'experimental philosophy' had been used with a variety of senses and that it is easy to regard the phenomenon of experimental philosophy around the time of the Restoration as more amorphous than we are urging here. Our claim is that Boyle, and no doubt others in his group, was developing a new account of the method by which we acquire knowledge of nature. This is the primary referent of the term 'experimental philosophy' in Boyle's writings in this period. Naturally the *practice* of this method could also be called experimental philosophy, as could the *knowledge* that this method produced, what Boyle and others also called experimental learning.[11] Yet the fulcrum, so to speak, of the whole phenomenon that was experimental philosophy was the philosophical thesis that knowledge of nature is to be acquired in a particular way.

Thus, experimental philosophy was a new philosophy and it was often labelled as such during this period.[12] However, experimental philosophy had no monopoly on the term 'new philosophy', which had been used, famously, by John Donne as early as 1611.[13] By the time that experimental philosophy emerged in the seventeenth century, there had been many new developments in philosophy in general and natural philosophy in particular; these too were

[9] They are so described in the 2nd edition; Boyle 1661, sig. A3^{v}.
[10] See Frank 1980, pp. 123–6.
[11] *Boyle Corr.*, 1, p. 214; B 2 18, 20, 25, and 27.
[12] See, for example, Oldenburg 1666b, p. 192; Simpson 1670, p. 50 and for the Latin equivalent Parker 1665, title page.
[13] Donne 1611, sig. B1^{r}.

called the new philosophy, and the philosophers involved were sometimes called new philosophers or *novatores*. For example, Descartes' philosophy is frequently called the new philosophy through to the end of the century, and a number of neo-Cartesians who flourished from 1670 to 1690 in France were called *novatores*.[14] And yet Cartesian philosophy was not normally regarded as experimental philosophy at all, but rather as a form of speculative philosophy. One needs to be cautious, therefore, when encountering the term 'new philosophy' in the historical record, because its extension is far broader than that of 'experimental philosophy'.[15]

At this point, it is worth recalling our claim in the Introduction that in seventeenth-century natural philosophy there was a deep problem concerning the acquisition of knowledge of the inner natures of natural things and explanations of their behaviour. Once knowledge of an essence had been acquired, there was a further issue as to how to construct a science of that substance or quality. How, for example, should one go about constructing a science of motion or of gold? The traditional and widely accepted solution derived from Aristotle. Once we have knowledge of the essence of a substance, we can then express this as a universal, necessary proposition, such as 'All men are rational animals'. Such propositions then become premises in scientific syllogisms. Scientific syllogisms are those that do not merely have a valid form but are explanatory insofar as they provide causal knowledge.[16] The ideal is, therefore, that given a sufficient stock of necessary propositions concerning essences, together with the common principles that pertain to all disciplines, we are able to construct a demonstrative science.

This account of the acquisition of natural philosophical knowledge came under sustained pressure in the seventeenth century. Aware of the risk of anachronism, we offer here the following rational reconstruction of the main

[14] See Roux 2013a; Garber 2022.

[15] Simon Patrick's *A Brief Account of the New Sect of Latitude-Men together with some Reflections upon the New Philosophy*, 1662, includes Gilbert, Galileo, Descartes, Gassendi, and the new air-pump experiments under the term 'new philosophy'. William Whiston (1698, preface) speaks of 'the New Philosophy; I mean particularly the *Cartesian*', and Sir Peter Pett (1688, p. 129) speaks of the Cartesians and Gassendists in France as new philosophers. By contrast, David Abercrombie (1687, p. 156) lists Descartes, Bacon, and Boyle as authors of the new philosophy and Anthony Wood (1692, p. 838) speaks of Boyle as 'the greatest promoter of New Philosophy' among the Fellows of the early Royal Society. In *Specific Medicines*, Boyle claims that many call the corpuscular philosophy the new philosophy, B 10 353.

[16] It is convenient to consider the question of the nature of causal knowledge in terms of either the theory of essences or the theory of demonstration. For background on causal demonstrations, see Mancosu 1996, pp. 10–15; Dear 1995, chapter 2. For the changing conception of causal knowledge in the seventeenth century, see Pasnau 2017, pp. 1–20 and 154–5.

lines of response of proponents of experimental philosophy to the problems that beset the Aristotelian account of the acquisition of knowledge of nature.

First, there is the problem of using the senses to acquire knowledge of essential natures. Some critics of the Aristotelian approach, such as Descartes, claimed that we can know some essences a priori and that the Aristotelian claims about these essences were false or misguided. Experimental philosophers, by contrast, denied that we can have a priori knowledge of essences. This left them with a dilemma: either we cannot have knowledge of essential natures, in which case we need to reconceive the whole project of the science of nature, or we can only know essences a posteriori. For those who took this latter course, a second problem arose, the problem of certainty. How can we have a posteriori knowledge of necessary truths about the essences of things? And if we cannot acquire knowledge of necessary truths about nature, how can we be certain of the conclusions of the scientific syllogisms that constitute our science? Furthermore, how can we even be certain of generalisations inferred from particular instances? (In contemporary terms, this is the problem of the fallibility of induction.) Third, and finally, there is the problem of constructing a science or system of knowledge once we have knowledge of essences. Can we construct a science on principles that might be liable to exceptions? And how adequate is Aristotle's theory of demonstration for the construction of a science of nature?

A number of relatively novel solutions were brought to bear on these problems in the seventeenth century. Four are relevant here. The first was Francis Bacon's attempt, albeit never completed, to develop a theory of *induction* that could circumvent the problem of the fallibility of induction. Surprisingly, this solution was of little interest to the first generation of experimental philosophers. The second approach was to attempt to develop an account of demonstrative reasoning that could accommodate propositions derived from experimental evidence. Pierre Gassendi and Joachim Jungius took this course, and, while they were applauded by some of the first generation of experimental philosophers, this approach was not to become a feature of experimental philosophy.[17]

Instead, the experimental philosophers, on the whole, took a third approach, which was to defer, perhaps for generations, the project of constructing a demonstrative science of particular substances and qualities and to examine particulars in a systematic and ordered manner. This involved putting some old epistemic categories to new uses. The notion of *matters of fact* became the central epistemic category for unmediated token observations and experiments,[18] and the notion of *testimony*, that is, testimony to matters of

[17] For Gassendi, see Fisher 2005, chapters 4 and 5. For Jungius, see Clucas 2010.
[18] See Serjeantson 2006 and Wootton 2015, chapter 7.

fact, became an important epistemic notion for mediated observations and experiments.[19]

A fourth approach, often combined with the third, was to aim, as Bacon had suggested, at *intermediate causal explanations* rather than ultimate ones.[20] This approach required an important change to the accepted notion of what a causal explanation is, and the approach was taken up by the first generation of experimental philosophers, as we shall see in Section 2.2. Thus, intermediate causal explanations, matters of fact, and mediated matters of fact acquired through testimony became important new epistemic categories in natural philosophy for addressing an age-old problem.

2.2 The Kernel of Boyle's Experimental Philosophy

The answer that Boyle provided for these old problems goes to the heart of the new experimental philosophy. The historical record does not allow us to claim that these ideas originate with Boyle; rather, he was systematising a set of epistemic and procedural values associated with experiment that pervaded his milieu. Thus, for example, in 1652 Seth Ward, a member of the Oxford club, claimed in a letter to Sir Justinian Isham that one of the aims of the group was 'according to our opportunityes to make inquisitive experiments, the end is that out of a sufficient number of such experiments, the way of nature in workeing may be discovered' (H. W. Robinson 1949, p. 69). Indeed, Boyle's immediate contemporaries did not regard him as the inventor of experimental philosophy (though some in subsequent generations considered him to be the father of experimental philosophy).[21] Nor did he regard himself as an innovator in this regard. He thought that a form of experimental philosophy was practised as far back as Democritus.[22] Yet his early methodological writings, especially his 'Proëmial Essay' to *Certain Physiological Essays* (1661), are the first published writings to spell out this new approach to the science of nature.

Boyle claims to have written his 'Proëmial Essay' in 1657.[23] It is almost certainly adumbrated in his very early 'Of Naturall Philosophie', written between 1649 and 1653, which sets out directions for making experiments and observations.[24] He

[19] See Serjeantson 1999.
[20] See *Novum organum*, bk. 1, aph. 65, 69, 104, OFB 11 103, 111, and 161. See also Jardine 1974, pp. 99–101.
[21] See, for example, d'Alembert, PD, p. 86.
[22] See Levitin 2014a, 2015, pp. 378–87.
[23] B 2 5.
[24] Transcribed in M. Hunter 2000, pp. 30–1.

begins with an assessment of some of the leading natural philosophies that were of influence in his day:

> I am very sensible of my being far from having such a stock of Experiments and Observations, as I judge requisite to write Systematically; and I am apt to impute many of the Deficiencies to be met with in the Theories and Reasonings of such great Wits as *Aristotle*, *Campanella*, and some other celebrated Philosophers, chiefly to this very thing, that they have too hastily, and either upon a few Observations, or at least without a competent number of Experiments, presum'd to establish Principles, and deliver Axioms. (B 2 13)

The problem with Aristotle and Campanella, for example, is that they superstructed their systems on 'principles and axioms' that are based upon too slim an evidential base. Boyle accepts the ideal of a demonstrative science based upon principles and axioms; it is the inadequate evidential grounds for the principles and axioms themselves to which he objects. He conceives of the solution in quantitative terms. Natural philosophers should:

> set themselves diligently and industriously to make Experiments and collect Observations, without being over-forward to establish Principles and Axioms, believing it uneasie to erect such Theories as are capable to explicate all the Phaenomena of Nature, before they have been able to take notice of the tenth part of those Phaenomena that are to be explicated. (B 2 14)

Returning to his point about quantitative evidence, Boyle asserts:

> That then that I wish for, as to Systems, is this, That men in the first place would forbear to establish any Theory, till they have consulted with (though not a fully competent number of Experiments, such as may afford them all the Phaenomena to be explicated by that Theory, yet) a considerable number of Experiments in proportion to the comprehensiveness of the Theory to be erected on them. (B 2 14)

Finally, for Boyle, even with sufficient evidence one should adopt what we would now call a fallibilist stance: 'I would have such kind of superstructures look'd upon only as temporary ones' (B 2 14). The only things that Boyle will remain certain of are matters of fact: 'I dare speak confidently and positively of very few things, except Matters of Fact' (B 2 19). Though he will appeal to the observations of others hoping 'that their Testimonies will as well be illustrated by mine, as mine by their's' (B 2 28).

In summary then, up to this point Boyle's position is the following. First, experiment and observation have epistemic priority: one should accept only those principles and axioms in natural philosophy that are based upon sufficient experimental and observational evidence, and one should avoid constructing a theory without recourse to experiment and observation. Second,

once a theory is constructed, one should be prepared to revise it in the light of new experimental evidence. We claim that these two claims are core doctrines of experimental philosophy. They account for its emphasis on experiment and for its decrying of speculation and hypotheses.

Yet in the 'Proëmial Essay', Boyle makes a number of additional claims, claims that are integral to his approach but which are not themselves necessary tenets of the new experimental philosophy. First, while Boyle believed in ultimate causes underlying natural phenomena, he also acquiesced in Bacon's conception of a scale of causes and the need to discover intermediate causes en route to ultimate explanations:

> there are oftentimes so many subordinate Causes between particular Effects and the most General Causes of things, that there is left a large field wherein to exercise Mens Industry and Reason, if they will but solidly enough deduce the Properties of things from more general and familiar Qualities, and also intermediate Causes (if I may so call them) from one another. (B 2 23)

One such intermediate cause that was of great importance for Boyle at the time that he composed the 'Proëmial Essay' is the spring of the air.[25] Boyle was aware that this quality was not one of those causes 'that are the highest in the scale or series of Causes' (B 2 21), but that he had to be content with its intermediate status.

Second, Boyle believes that one can reason upon experiments. Indeed, as early as his 'Of Naturall Philosophie' he claimed that there are two principles of natural philosophy, the senses and reason. In the 'Proëmial Essay', he continues: 'Not that I at all disallow the use of Reasoning upon Experiments, or the endeavouring to discern as early as we can the Confederations, and Differences, and Tendencies of things: For such an absolute suspension of the exercise of Reasoning were exceeding troublesome, if not impossible' (B 2 14). It is hardly surprising then to find that Boyle wrote quite extensively on the relation between experimental philosophy and speculative philosophy and on the uses of reason to the experimental philosopher. For example, in a catalogue of his unpublished works dating from 1684 there is listed a work entitled 'Of Usefulnes of Speculative & Experimental Philosophy to one another'. Prefatory material and two contents lists for a work on this subject survive among Boyle's papers, and a projected essay on the subject to be published in a new edition of *Usefulness* was mentioned to Oldenburg as early as 1666.[26]

[25] See Anstey 2002; Chalmers 2012.

[26] For the title of this essay in 1684, see B 14 342, and for the 1666 version, see B 13 lxx. For the contents lists, see Sargent 1995, p. 164 and Royal Society Boyle Papers, vol. 10, fol. 127^{r}, and for the prefatory material, see vol. 9, fols. 18, 26, and 59.

2.3 Experimental Philosophy and the Early Royal Society

It is pretty clear from these references in Boyle's writings that by the late 1650s he was using the term 'experimental philosophy' to describe the sort of natural philosophy theorised and practised by himself and the other members of the Oxford experimental philosophy club. During the flurry of publishing activity on Boyle's part around 1660, the Royal Society of London was formed, and the documentary evidence of its foundation and rationale reveals that the young Boyle was just one of a number of virtuosi who were caught up with this new experimental philosophy. Another was Christopher Wren, who, in his *c*. 1660 preamble to a draft Charter to incorporate the Royal Society, claimed both reason and experience had confirmed 'that we prosecute effectually the Advancement of Natural Experimental Philosophy'. It is this branch of knowledge 'which comprehends all that is required towards those Intentions we have recited' (C. Wren 1750, p. 197).

Within a year, Abraham Cowley had published his *A Proposition for the Advancement of Experimental Philosophy*, which proposed an organisational structure for the Royal Society modelled on Bacon's Solomon's House, a structure specifically tailored to promote experimental philosophy. Most copies of this work have a prefatory epistle addressed to 'the Honourable Society for the Advancement of Experimental Philosophy' penned by Boyle's friend Peter Pett and indicating the close ties that the newly founded Society was thought to have with experimental philosophy.

Another early proposal, similar to that of Wren, for 'The business & designe of the Royall Society' came from Sir Robert Moray. While Moray does not use the term 'experimental philosophy', his methodological stance is of a piece with that espoused by Boyle in his 'Proëmial Essay':

> This Society will not own any Hypothesis, systeme, or doctrine of the principles of Naturall philosophy, proposed, or maintained by any Philosopher Auncient or Moderne, nor the explication of any phaenomenon, where recourse must be had to Originall causes . . . Nor dogmatically define, nor fixe Axiomes of Scientificall things, but will question and canvas all opinions[,] adopting nor adhering to none, till by mature debate & clear arguments, chiefly such as are deduced from legittimate experiments, the trueth of such positions be demonstrated invincibly.
>
> (M. Hunter 1995, p. 173)

It is hardly surprising, therefore, that within a few years members of the Society began to publish works of experimental philosophy. After the appearance of Boyle's *Usefulness of Experimental Natural Philosophy* in 1663, another Fellow, Henry Power, published a work in 1664 entitled simply *Experimental Philosophy*. In the same year, Robert Hooke, who had worked as Boyle's assistant in Oxford, was appointed to the position of Curator of Experiments at the Society, and in November of 1664 it was decided that he was to receive

a stipend for 'reading lectures of experimental philosophy' (M. Hunter 1989c, p. 294). Though the title of these lectures was to change to reflect the more focused natural historical agenda of the early Society, it is further evidence of the general identification of the new experimental philosophy with the activities of the Society.

Power's work was the first to contain microscopial observations, reflecting what Wren regarded as a crucial recent change in the way that natural philosophy was practised: 'natural Philosophy having of late been order'd into a geometrical Way of reasoning from ocular Experiment, that it might prove a real Science of Nature, not an Hypothesis of what Nature might be' (C. Wren 1750, p. 204). Wren's reference to 'ocular Experiment' recalls Hooke's *Micrographia* of 1665, a work of experimental philosophy par excellence and the most famous of all early British works of microscopy.[27] Moreover, Wren's talk of proving 'a real Science' also echoes Hooke's claim in *Micrographia* about the real, that is, the experimental philosophy in contrast to speculative philosophy:

> The *real*, the *mechanical*, the *experimental* Philosophy, which has this advantage over the Philosophy of *discourse* and *disputation*, that whereas that chiefly aims at the subtilty of its Deductions and Conclusions, without much regard to the first ground-work, which ought to be well laid on the Sense and Memory; so this intends the right ordering of them all, and the making them serviceable to each other.
>
> (Hooke 1665, Preface, sig. a3)[28]

What are we to make of all of this? We are not claiming that every Fellow of the early Royal Society adhered to the central tenets of experimental philosophy, or even that they could articulate what those tenets were by the mid-1660s. We are not claiming that every use of the term 'experimental philosophy' had exactly the same referent. Nor are we claiming that the new experimental philosophy accounted for all the activities of the Society. What we are claiming is that the historical record shows that, following its short gestation in Oxford, the movement of experimental philosophy, that is, the group of natural philosophers who self-identified with the central tenets of experimental philosophy and practised natural philosophy according to this method, as well as those within its ambit who advocated for it, first emerged in the Royal Society of London in the early 1660s.

Further layers of evidence can be adduced to establish these claims, such as the manner in which correspondents of the early Fellows described their

[27] Of course, Wren himself was an accomplished draughtsman of microscopial images. For Hooke's deference to Wren in this regard, see Hooke 1665, sig. g1.

[28] Quoted by Cavendish in her *Observations upon Experimental Philosophy*, Cavendish 2001 [1666/8], p. 49. See also, Sprat 1667, pp. 340 and 336.

activities. One might instance the divine Edward Stillingfleet, who wrote to Boyle in 1662:

> there is noe person in our nation hath more obliged the world then Yourselfe have done in the discourses You have lately made the world acquainted with, soe it is the earnest desire of all such who value reason & knowledge that You will please still to imploy Your excellent pen in a further discovery of those rich mines of experimentall philosophy, which with soe greate happynes & successe You have beene Conversant in. (*Boyle Corr.*, 2, p. 50)

Furthermore, the Royal Society continued to be regarded as the locus of experimental philosophy, which philosophy was understood by many to be the distinctive methodology of the Society for the remaining decades of the seventeenth century. Thus, when John Wallis claimed in his *A Discourse of Gravity and Gravitation* in late 1674 that it was written 'in Compliance with the Commands of this *Royal Society*, in order to the promoting of Experimental Philosophy' (Wallis 1675, p. 1), he was merely expressing a widely held sentiment about the Society's aims.

Again, the founders of the Dublin Philosophical Society, which formed in 1683, clearly viewed the Royal Society as the locus of a decisive change in the practice of natural philosophy.[29] For example, Sir George Ashe's statement of the aims of the Society define it as an offspring of the Royal Society of London. With reference to Charles II, Ashe waxes: 'in instituting the Royal Society, Captive truth was rescued from its former bondage, and clouded knowledge began to shine more bright; when instead of words and empty speculations, were introduced things and experiments, and the beautiful bosom of nature was exposed to view' (Hoppen 2008, 2, pp. 898–9).[30] The same tone is found in his contribution to the natural history of the air: 'natural philosophy (as is generally managed) is little else than a learned romance, which may amuse and divert, but can never satisfy the mind of man, which is fed only by experiment and demonstration, and not with gay empty speculations or spruce hypotheses' (Hoppen 2008, 1, p. 148).[31]

Another prominent member of the Dublin Society, William Molyneux, is even more explicit in the dedicatory letter to 'the Illustrious The Royal Society' in his *Dioptrica Nova* of 1692:

> I cannot omit expressing my Sence of that excellent Method of Experimental Philosophy, which now, By your Example and Incouragement, does so

[29] See Hoppen 1970, p. 23.

[30] From Sir George Ashe's Speech to Lord Clarendon. As for the Dublin Society, its rules state that the 'rector' of the Society is called 'vigorously upon all occasions to promote experimental philosophy, mathematics, medicine, mechanics, etc.' (Hoppen 2008, 2, p. 894). For the continued influence of experimental philosophy in the Dublin Society and on George Berkeley, see Nakano 2021.

[31] Read before the Dublin Philosophical Society on 25 October 1686.

> universally prevail . . . 'Tis wonderful to consider, how the Schools were formerly overrun with a senseless kind of Jargon, which they call'd *Philosophy* . . . The Commentators on *Aristotle* . . . have rendred *Physicks* an heap of Froathy Disputes, managing the whole Knowledge of Body and Motion . . . by Hypothetical Conjectures, confirm'd by plausible Arguments of Wit and Rhetorick, ordered in a Syllogistical form; and answering Objections in like manner: But never studied to prove their Opinions by Experiments. (W. Molyneux 1692, dedicatory epistle, sigs. A1–3)

Yet enough has been said here to establish the actual time and location of the origins of early modern experimental philosophy.

2.4 Early Opposition to Experimental Philosophy

A very effective way further to scrutinise the content of the new experimental philosophy is to examine the writings of its early critics and the defences of its early protagonists. And critics there were. From the mid-1660s, the Royal Society, which was viewed as the locus of the new experimental philosophy, faced opposition to the point that, within seven years of its founding, a propagandist history of the Society had appeared, Thomas Sprat's *History of the Royal-Society of London* of 1667.[32] Interestingly, Henry Oldenburg, in *c.* 1664–5, set out a number of anticipated 'Objection[s] Against the Experimental way of Philosophy' to be considered by Sprat in the writing of his history. These include problems with the purity of materials in chymical experiments and the general problem of variability in the conditions in which experiments are performed 'which makes the Experiments very obnoxious to contingencies' (M. Hunter 1989b, p. 68). The general fear was expressed as follows: 'If there be no agreement in Experiments, at least in many such, as are important to determine truth by[,] there appears small hope of ever raising a Systeme of solid Philosophy, etc.' (M. Hunter 1989b, p. 69). Oldenburg tendered his own answer to the objection: 'if the effects differ, it will put men upon investigating the causes of that difference, which must needs discover a great many considerable and luciferous things' (M. Hunter 1989b, p. 69). Sprat, for his part, responded to Oldenburg's anticipated objections to the unreliability of experiments in Part II of his *History*.[33]

Yet Sprat's defence of the Royal Society is far more broad-ranging than this, and it is important that we do not conflate all criticisms of the Society with the more pointed critique of experimental philosophy. To that end, we will examine two of the more articulate critical responses to this new movement in natural philosophy. Arguably the most astute of the early critics, and

[32] On the polemical background and motivations of Sprat's *History of the Royal-Society of London*, see P. B. Wood 1980 and M. Hunter 1989b.

[33] Sprat 1667, pp. 243–5. This was first pointed out by M. Hunter (1989b, p. 53).

certainly the most learned, was Meric Casaubon. His *A Letter . . . to Peter du Moulin . . . Concerning Natural experimental Philosophie, and some books lately set out about it* was printed in Cambridge in 1669. Casaubon's letter concerns the dismissive claims that promoters of 'this way of Philosophy, of late years much cried up in *London* and elsewhere' (such as Joseph Glanvill in his *Plus Ultra*[34]) have made concerning the learning of former ages. His first criticism is of the manner in which 'Practical useful learning' has been 'appropriated to the way now in use, by experiments', whereas those that 'go any other way' are called 'men of the Notional way', which produce '*useless*, *notional* and *unprofitable*' learning (Casaubon 1669, pp. 1, 4, and 5). Casaubon is not so much attacking experimental philosophy as defending learning that the promoters of experimental philosophy were branding as speculative philosophy.

In particular, Casaubon defends Aristotle from the charge of being a speculative philosopher. According to the experimental philosophers in question, Aristotle is falsely construed, 'as if his way had been, first, in the retiredness and secrecy forsooth of his contemplative brain, without the trouble and consideration of particular objects, to frame to himself *general Theories*, as certain principles, or fundamentals; and then to determine of the true nature of particular objects by those *Theories*' (Casaubon 1669, p. 9). Yet surely, complains Casaubon, any serious reading of Aristotle will give the lie to this interpretation:

> he [Aristotle] doth, as to matter of action, or success, prefer *experience* without *art* or knowledge, before *art* and knowledge, without *experience* . . . Not likely therefore that *Aristotle* would frame to himself . . . *general Theories*, not grounded at all, upon particular observations: but that he might be mistaken, or defective in particular observations . . . is very possible: and thereupon his *Theories*, by men of judgement and ingenuity, amended or perfected. (Casaubon 1669, p. 10)

Moreover, what use are 'particular observations until they be reduced to art or *theories*, that is, general rules or maxims' (Casaubon 1669, p. 10)? The crucial point here is that Casaubon was sensitive to the anti-speculative rhetoric of the experimental philosophers and reacted to their blanket and simplistic caricatures of Aristotle and others. In fact, he is not attacking the core ideas of experimental philosophy at all, but rather implying that its promoters' claims for novelty are overblown.

A second and earlier critic of experimental philosophy was the Duchess of Newcastle, Margaret Cavendish. Her *Observations upon Experimental Philosophy* contains the most sustained attack on experimental philosophy

[34] Oldenburg spoke of Glanvill's aim in *Plus Ultra* (1668) as 'to recommend and indicate the modern Experimentall Philosophers, by representing the advantages of this way of Trials, both for Light and Use, above that of former times' (*Oldenburg Corr.*, 3, p. 503).

that was published in the seventeenth century and is one of the few works that explicitly defends speculative philosophy over experimental.[35] Published first in 1666 and then in a revised second edition in 1668, Cavendish summarises her aim as follows: 'in this present work I intended nothing else, but to make reflexions upon *experimental philosophy*, and to explain some other points in *natural philosophy*, for the better understanding of my own opinions' (Cavendish 2001 [1666/8], p. 247). Indeed, she regards this as a natural progression from her previous writing: 'as I have had the courage to argue heretofore with some famous and eminent writers in speculative philosophy; so have I taken upon me in this present work, to make some reflextions also upon some of our modern experimental and dioptrical writers' (Cavendish 2001 [1666/8], p. 10). The chief of the speculative writers to whom she alludes are Descartes and Hobbes, whom she discussed in her *Philosophical Letters*. And, interestingly, she refers to 'dioptrical writers' in a manner similar to that of Wren cited above (Section 2.3). These include Henry Power and Robert Hooke.

Cavendish states her central thesis against experimental philosophy in the second section of Part One, entitled 'Of Art, and Experimental Philosophy'. When she speaks of art, she follows Hooke's use in *Micrographia*, referring loosely to the mechanical arts that are required for the construction of instruments and experiments. We quote the central thesis *in extenso*:

> I say, that sense, which is more apt to be deluded than reason, cannot be the ground of reason, no more than art can be the ground of nature: Wherefore discourse shall sooner find or trace nature's corporeal figurative motions, than deluding arts can inform the senses; For how can a fool order his understanding by art, if nature has made it defective? or, how can a wise man trust his senses, if either the objects be not truly presented according to their natural figure and shape, or if the senses be defective, either through age, sickness, or other accidents . . . And hence I conclude, that experimental and mechanic philosophy cannot be above the speculative part, by reason most experiments have their rise from the speculative, so that the artist or mechanic is but a servant to the student.
>
> (Cavendish 2001 [1666/8], p. 49)

The argument against experiment, and by extension against experimental philosophy, is an argument from the fallibility of the senses over and against reason. In the following section, Cavendish goes on to claim that experimental philosophy also lacks utility: it has not issued in anything worthwhile.

> Could experimental philosophers find out more beneficial arts than our forefathers have done . . . it would not only be worth their labour, but of as much praise as could be given to them: But, as boys that play with watery

[35] Surprisingly, the editor of the Cambridge edition of Cavendish's *Observations* omits any reference to experimental or speculative philosophy in either the introduction or the index. See Cavendish 2001 [1666/8], pp. x–xxxvi.

> bubbles or fling dust into each other's eyes, or make a hobbyhorse of snow, are worthy of reproof rather than praise, for wasting their time with useless sports; so those that addict themselves to unprofitable arts, spend more time than they reap benefit thereby.
>
> (Cavendish 2001 [1666/8], pp. 51–2)

Her third criticism is that the instruments that they deploy are untrustworthy:

> experimental philosophy has but a brittle, inconstant, and uncertain ground. And these artificial instruments, as microscopes, telescopes, and the like, which are now so highly applauded, who knows but they may within a short time have the same fate; and upon a better and more rational enquiry, be found deluders, rather than true informers.
>
> (Cavendish 2001 [1666/8], p. 99)

Part of the problem with artificial instruments, according to Cavendish, is their limited range: 'those that employ their time in artificial experiments, consider only nature's sporting or playing actions' (Cavendish 2001 [1666/8], p. 105)[36] rather than penetrating her inner secrets. Interestingly, Cavendish also claims that the experimental philosophers' preference for observation and experiment over reason makes them more dogmatic: 'preferring art and experiments, before reason; which makes them stick so close to some particular opinions, and particular sorts of motions or parts; as if there were no more motions, parts, or creatures in nature, than what they see and find out by their artificial experiments' (Cavendish 2001 [1666/8], p. 99).[37]

Ironically, this is exactly the complaint that the experimental philosophers levelled against speculative philosophers: they regarded a commitment to natural philosophical theory as an impediment to the correct understanding of observation and experiment. Ultimately, however, it is the relative unreliability of sense versus reason that is the deciding issue for Cavendish: 'the bare authority of an experimental philosopher is sufficient to them to decide all controversies, and to pronounce the truth without any appeal to reason; as if they only had the infallible truth of nature, and engrossed all knowledge to themselves. Thus reason must stoop to sense' (Cavendish 2001 [1666/8], pp. 196–7). Her conclusion is unavoidable: 'if reason be above sense, then speculative philosophy ought to be preferred before the experimental, because there can no reason be given for anything without it' (Cavendish 2001 [1666/8], p. 241).

These criticisms of experimental philosophy, whatever their merits, reveal just what was at stake in English natural philosophy in the 1660s. Not only do they shed light on the contours of experimental philosophy, but they also bring into sharp relief the ESD and the manner in which it was deployed to demarcate markedly different approaches to the acquisition of knowledge in natural philosophy.

[36] See also Cavendish 2001 [1666/8], pp. 239–40 for criticism of chemists' experiments.
[37] John Keill was to make a similar criticism in Keill 1702, p. 6 = Keill 1720, p. 7.

2.5 Experimental Philosophy and Medicine

Natural philosophy, however, was not the only domain of knowledge in which experimental philosophy was being applied. The close connection between many of the early Fellows of the Society and medical practitioners meant that a host of physicians sought to apply the new method to therapeutic medicine. Now, the nature and practice of experimental philosophy among English physicians is a fascinating and complex story in its own right. It involves not merely the rivalry between the chymical and Galenic physicians, but also the often-fraught relations between the Royal Society and the London College of Physicians, as well as the fortunes of various well-known physicians, such as Thomas Sydenham, who were Fellows of neither the Society nor the College.[38]

Moreover, it is somewhat superficial to presume that there was a clear division of labour and interests between natural philosophers and physicians in this period. In many ways, their interests and practices were continuous. Boyle, for example, wrote extensively on medical matters as an experimental philosopher.[39] The philosopher John Locke was a physician and an advocate of experimental philosophy with strong interests in natural philosophy. And there was a group of 'virtuoso-physicians', such as Daniel Coxe, Christopher Merrett, Jonathan Goddard, and Timothy Clarke, who were members of both the Society and the College and who advocated experimental philosophy.[40] The most that we can hope to do here, however, is simply to highlight the uptake of experimental philosophy amongst English physicians from the mid-1660s, without offering any analysis of the motivations, development, and outcomes of their appropriation of this new approach to natural philosophy.

With regard to the chymical physicians, it was only natural that they should consider the entrenched hegemonic Galenic theory as highly speculative. They sought to develop effective chymical remedies and saw themselves as 'setting the whole frame of Physick upon a new foot of Operative and Experimental Philosophy' (Nedham in Bolnest 1665, letter to the author, sig. A7^{v}). The polemicist for their cause, Marchamont Nedham, expressed

[38] For the relations between the Royal Society and the College, see Cook 1989, and for the relations between medicine and the new experimental philosophy, see Cook 1990. For Sydenham and experimental philosophy, see Anstey 2011b.

[39] See Boyle's *Usefulness of Experimental Philosophy*, B 3; M. Hunter 2000, chapter 8. For Boyle on the relation between natural philosophy and medicine, see, for example, B 10 353.

[40] Daniel Coxe, for example, speaks of 'my darling Studies of Experimental Philosophy, and Physick (most pleasing and profitable imployments)', Coxe 1669, sig. A2^{r}. For the virtuoso-physicians' defence of experimental philosophy, see Cook 1986, pp. 162–82 and 1989, pp. 256–65.

the common attitude of the chymical physicians in his tract *Medela medicinae* of 1665:

> a Doctor bred up in the Contemplative Philosophy of the Schools, may be a Scholar and a very fine Gentleman; but what is that to the Curing of a Disease, or the rousing of a Heart-sick Man from his bed of Languishment? This is to be expected rather from one that is qualified for the work by acquaintance with Mechanick and *Experimental Philosophy*. (Nedham 1665, p. 255)

A few years later, the chymical physician Everard Maynwaring described the 'compleat' chymical physician as follows:

> He knows, and can manifest it; that the Medicinal Science requires alteration in some fundamentals, generally received; that many derivative Doctrines must fall to the ground; that the Professors in this Faculty are not to sit down & be satisfied with the Labours of our Predecessors (though worthy to be reverenced and recorded for their great endeavours) but that there is much work yet left to be finished; and much to be unravelled, that is supposed perfect ... he is not only a speculator of truth; but is trained up in Experimental Philosophy, and confirms his notions by Chymical practice and sensible operations.
> (Maynwaring 1668, pp. 84–5)

This sentiment continued amongst many physicians in Britain through to the end of the century. John Colbatch expresses his aspirations in a similar vein: 'I hope by means of Experimental Philosophy, so happily begun and encouraged by that Admirable and never sufficiently to be valued Mr. *Boyl*, to see the Art of Physick arrive to as great a Certainty and Perfection, as other Arts and Sciences' (Colbatch 1696, p. 142).

Interestingly, by the end of the century the Italian physician Gorgio Baglivi was penning similar views. In his *The Practice of Physick*, which appeared in Latin in 1696 and in English translation in 1704, Baglivi praises the Greek physicians such as Hippocrates and criticises those who subsequently overly relied on theory: 'the Speculative sorry Advances of later Upstarts; unless they give less Credit to imaginary Opinions, and conclude, that *Medicine* ought not to be confin'd to the narrow Limits of our Reason.' He goes on to speak of more recent developments: 'Whatever it is that distinguishes the Modern Theory from the ancient Ignorance, 'tis all owing to the Experimental Philosophy of this Age' (Baglivi 1704, pp. 2–3).

At the heart of Baglivi's commitment to the application of experimental philosophy in physic is his commitment to the construction of natural histories of disease.[41] This awareness and acceptance of experimental philosophy by an eminent Italian physician leads naturally to the question as to whether any

[41] Baglivi 1704, pp. 210–30.

Italian and other Continental natural philosophers also identified with experimental philosophy. And it is to this question that we now turn.

2.6 Experimental Philosophy on the Continent

It is hardly surprising that there is evidence of the spread of experimental philosophy to Italy. For while there are many parallels between the fledgling Royal Society and the short-lived Accademia del Cimento, the latter's demise coincided with the emergence of experimental philosophy. The *Saggi di naturali esperienze*, the only group publication issuing from the Accademia, expresses their design in terms that would have been entirely familiar to the first generation of English experimental philosophers:

> We are unwilling any should imagine, That we pretend in this Publication, a Perfect Work; or in the least, an Exact Module of a large *Experimental History*; conscious to our selves, that more Time, and greater Abilities are necessary to so vast a Design . . . if sometimes, as a Transition from one *Experiment* [*esperienza*] to another, or upon what occasion soever, there shall be inserted any hints of Speculation [*cosa specolativa*], we Request they may be taken always for the thoughts, and particular sense of some one of the Members, but not imputed to the whole *Academy*, whose sole Design is to make *Experiments* and Relate them.
>
> (Magalotti 1667, sig. +2 4, trans. Waller 1684, sigs. b2^{v}–b3^{r})

One can also find endorsements of experimental philosophy by individual authors throughout Italy: in Bologna (Montanari 1667), Florence (Magalotti 1667, Redi 1909 [1668]), Naples (Di Capua 1681), and Messina (Scilla 1996 [1670]), in addition to Malpighi (1980 [1698]), who worked throughout the Peninsula, and even Jesuits teaching in Brescia and Rome (Bartoli 1980 [1677], Lana Terzi 1977 [1670]).

These men were not merely paying lip service to experimental philosophy. Geminiaro Montanari's writings, for example, reveal explicit, self-conscious views on what we can know and how we should proceed in natural philosophy, along with rather detailed accounts of his actual experiments. He endorses many typical views of experimental philosophers. He criticises Aristotle and the Scholastics for following a wrong method.[42] He vigorously claims that natural philosophy must be based on experiences (*esperienze*, *experimenta*; 1667, pp. 5–6), and he stresses their primacy over theories. He insists that experiences must be first-hand[43] and that other people's experiments must be replicated in the course of a public, collaborative experimental enterprise.[44] He adopts a two-stage method[45] that

[42] Montanari 1980, p. 549.
[43] Montanari 1694 [1675], p. 523.
[44] Montanari 1676, p. 62.
[45] See, for example, Montanari 1667, 1671.

starts with the compilation of Baconian natural histories. He mentions induction (1980, p. 540), but, like most British experimental philosophers, he does not take up Bacon's theory of induction, and he is rather vague on how, exactly, an induction (sometimes 'deduction') from the phenomena is supposed to unfold. The strength of Montanari's adherence to the epistemic limitations of experimental philosophy is reflected in his claim that we cannot achieve any certainty in metaphysics and psychology (study of the soul) because they go beyond the bounds of sense perception.[46]

Moreover, experimental philosophy also had an institutional presence in Italy in the latter decades of the seventeenth century, over and above the short-lived Accademia del Cimento. Take, for example, the Sarotti Academy in Venice. It was founded in 1681 on the return of Giovanni Ambrosio Sarotti from England, where he had been nominated by Boyle and elected a Fellow of the Royal Society in 1679.[47] Boyle's assistant Denis Papin attended meetings of the Venetian academy over a period of two years and later performed one of their air-pump experiments before the Royal Society on 15 December 1686.[48] Academies in Bologna, Siena, and Verona were called academies of experimental philosophy or described as practising experimental philosophy.[49]

In contrast to Italy, it is difficult to find explicit endorsements of experimental philosophy in France in the last four decades of the seventeenth century. More work needs to be done on the reception of experimental philosophy in France in this period, but it is worth reflecting on the distinctive profile of French natural philosophy as we seek explanations of the new movement's inability to take root there. No one denies that from the 1640s experiment played an exciting role in French intellectual life. The writings of Marin Mersenne and Pierre Gassendi, Pascal's experiments in pneumatics and hydrostatics, and the work of Jean Pecquet and Gilles Personne de Roberval are well-documented examples of the impact of experiment.[50] Moreover, while the salons in Paris, such as the Montmor academy, seem to have had little place for serious experimentation in the period leading up to the formation of the Académie des Sciences,[51] at least from 1661 there was an increasing desire among a small group of savants to, as Jean Chapelain put it, 'apply ourselves to

[46] Montanari 1971, p. 199. For further discussion, see Vanzo 2016b, p. 56.
[47] See Birch 1756–7, 3, p. 510.
[48] See Birch 1756–7, 4, p. 513. See also Talas 2013, p. 51.
[49] On Bologna, see the subtitle of Guglielmini 1688 and the title of Montanari 1780. The statute of the Accademia dei Fisiocritici of Siena states that 'experimental philosophy' deserves 'the name of good, true, and healthy philosophy' (Accademia dei Fisiocritici 1691, 31). According to an account of its foundation, the Accademia degli Aletofili of Verona was established to spread 'the healthier experimental philosophy' (Anon. 1716, p. 219).
[50] For a brief survey, see McClaughlin 1996, pp. 462–71.
[51] See Roux 2013b.

experiments in favor of all other exercises where only the mind takes part' (Roux 2013b, p. 66).[52] In this, they were self-consciously emulating the experimental philosophy of the Royal Society.

Furthermore, no one denies that some of the main writings of English experimental philosophers were available and read in France. Huygens was reading the Latin translation of Boyle's *Spring of the Air* in September 1661, within months of its appearance, and was keen to see his *Sceptical Chymist*.[53] Pierre Briot's library contained the leading works of Boyle, Hooke's *Micrographia*, and Power's *Experimental Philosophy*, as well as Cavendish's critical *Observations*.[54] Jean-Baptiste du Hamel, the Secretary of the Académie des Sciences, read many of Boyle's works, including *Spring of the Air*, *Sceptical Chymist*, *Usefulness of Experimental Natural Philosophy*, *Colours*, and *Forms and Qualities*. Samuel Cottereau du Clos was a critical reader of the Latin translation of Boyle's *Certain Physiological Essays*.[55] Yet it is hard to find any French natural philosopher, apart from du Hamel, who openly identified with the movement.

One explanation of this can be found in the recent work of Sophie Roux. Roux is concerned with a natural fault line within French natural philosophy in the period from 1670 to 1690 between the *novatores* and the old guard. While Roux's thesis is developed without reference to experimental philosophy, its application to this new development in British natural philosophy seems entirely natural.

A strict specification of determinate groups of old and new philosophers in France at this time is bound to seem artificial; nevertheless, there were certain *novatores* who came in for criticism by a group of more traditional thinkers. Among the old philosophers, Roux includes Ignace-Gaston Pardies, Louis Le Valois, Honoré Fabri, Jean-Baptiste de La Grange, Antoine Rochon, and Pierre Daniel Huet.[56] The more prominent new philosophers included Gérauld de Cordemoy, Louis de la Forge, Nicolas Malebranche, Pierre-Sylvain Régis, Nicolas Poisson, Bernard Lamy, Claude Gadroys, and Jacques Rohault.[57] All of these new thinkers were associated with the development and promotion of Cartesianism, which flourished in France in the 1670s and 1680s. Our interest is in the criticisms of the *novatores* by the old philosophers. Roux rightly points out that the new philosophers were criticised on two grounds. First, their attempts to provide corpuscular explanations of phenomena 'are *only* probable, *just* hypotheses, *simple* fictions' (Roux 2013a, p. 83). Second, they were criticised for their

[52] See Chapelain to Huygens, 30 May 1661, Huygens 1888–1950, 3, p. 273 and p. 279.
[53] Huygens 1888–1950, 22, p. 72.
[54] See Anon. 1679, pp. 38, 54, 59–60, 68.
[55] For du Hamel, see his 1672, pp. 413–23, 1678, 3, pp. 165–79 and 4, pp. 187–201; for du Clos, see Franckowiak 2013.
[56] Roux 2013a, pp. 80–1.
[57] Roux 2013a, pp. 67, 71–2.

'inability . . . to take the experimental character of the new science seriously' (Roux 2013a, p. 85). Roux has explored these criticisms in detail, particularly in the writings of the savant Edme Mariotte and the philosopher Antoine Rochon.[58] We will adduce further evidence that these criticisms were justified through an examination of the writings of Jacques Rohault.

Of all the French neo-Cartesians, Rohault is most frequently associated with experiments. His *Traité de physique*, first published in 1671, contains reports of numerous experiments. In his Preface, Rohault accords a central role to experiments in natural philosophy: 'Experiments therefore are necessary to establish Natural Philosophy' (Rohault 1723, 1, sig. A7^{v}).[59] He goes on to claim that we need the right mix of experiments and reason if we are to progress in natural philosophy. This sounds like grist to the experimental philosophers' mill. However, all is not as it might seem. For he proceeds to affirm the authority of the ancients, telling us that 'I have taken all the general Notions from *Aristotle*, either for the establishing the Principles of natural Things, or the chief Properties of them'. Thus, he has 'rejected *a Vacuum* and *Atoms* . . . which I think are Things contrary to what is firmly established by *Aristotle*' (Rohault 1723, 1, sig. b6^{r}). Then in chapters five and six of Part One he lays out the principal axioms of natural philosophy and the principles of natural things. This is precisely the method that the experimental philosophers opposed, the superstructing of a natural philosophy upon axioms and principles established a priori.[60] Indeed, Rohault goes on in the very next chapter to reason from these axioms and principles to that quintessential Cartesian thesis that the essence of matter is extension.[61] The first corollary that he draws from this is '*that what the Philosophers call a* Vacuum *cannot possibly be*' (Rohault 1723, 1, p. 27). Then, in his discussions of a series of experiments on suction and the Torricellian apparatus, Rohault consistently interprets the natural phenomena revealed by the experiments in terms of his Cartesian plenist metaphysics. For example, he claims that the space above the mercury column of the apparatus is filled with a subtle matter: 'It may here be demanded, how the subtil Matter, which fills the Top of the Tube, gets through: To which it may be answered; that it seems rather to pass through the Pores of the Glass, than those of the Quicksilver' (Rohault 1723, 1, p. 65 = Rohault 1671, p. 84).

[58] Roux 2013b.

[59] English translations are taken from Rohault 1723. See Rohault 1671, sig. é^{r}: 'Les expériences sont donc nécessaires pour l'établissement de la Physique.'

[60] As Dobre puts it (2019, p. 393): 'one should notice that no testing of the fundamental ontological principles is done'.

[61] See Rohault 1723, 1, p. 24. The same can be said of the Cartesian Antoine Le Grand in England; see Le Grand 1673, pp. 9–15 for his Cartesian interpretation of the Torricellian apparatus, and 1694, sig. A5^{r} for an explicit commitment to the method of speculation.

There are two surprising features of Rohault's discussion here. The first is the manner in which he is allowing Cartesian theory to constrain his interpretation of the phenomena.[62] This is exactly the sort of natural philosophical methodology that experimental philosophers characterised as speculative philosophy and to which they were vehemently opposed. The second is the fact that the whole treatment of the issues of suction and the Torricellian apparatus are dislocated from the extensive international discussion of these phenomena from the previous decade. There is no mention of Boyle's findings in *Spring of the Air* or of the attacks by Hobbes, Linus, and Anton Deusing and Boyle's responses.[63] There is no mention of Christiaan Huygens' experiments with his air pump, even though Rohault had been told about them by early 1662.[64]

As Roux has shown, this is characteristic of the neo-Cartesians rather than being a peculiar feature of Rohault's approach to observation and experiment, and it goes a long way to explaining the absence of experimental philosophers in later seventeenth-century France.[65] Interestingly, a later, parallel development is found in Leiden in the Netherlands. Burchard de Volder is credited with being the first natural philosopher to introduce experiments into a Dutch university. Yet de Volder remained a committed, if cautious, Cartesian until the end of the seventeenth century and appears to have used experiments to illustrate and confirm or disconfirm speculative natural philosophical theory rather than as a heuristic device for acquiring new knowledge of nature. In this regard, it is rather telling that he framed his request to the University of Leiden for the construction of a physics theatre for the performance of experiments in the following terms: 'so that by experiment the truth and certainty of the theories taught in theoretical natural philosophy might be demonstrated'.[66] De Volder – like Rohault, whose *Traité* he used in his lectures[67] – was a great advocate of experiment,[68] but he is not naturally described as an experimental philosopher.

[62] For a similar example, Rohault's explanation of a syringe, see Roux 2013b, pp. 55–6.

[63] See Shapin and Schaffer 1985 for Boyle, Linus, and Hobbes on the spring of the air. See also Deusing 1661. For a Cartesian interpretation of Boyle's air-pump experiments, see Clerke 1662.

[64] Huygens 1888–1950, 4, p. 11.

[65] Roux 2013a, 2013b. On Robert Desgabets's similar approach to experiment, see Easton 2013.

[66] Cited from Nyden 2013, p. 233, changing Nyden's 'physics' to 'natural philosophy'. The original Dutch has 'Physica'. We would like to thank Wiep van Bunge for assistance on this point. For background to the use of experiments at the University of Leiden, see Strazzoni 2019, pp. 64–7.

[67] See Le Clerc 1709, p. 398.

[68] See, for example, the extant set of student notes from his experimental demonstrations is entitled 'Experimenta philosophica naturalia' ('Natural philosophical experiments'), transcribed in Strazzoni 2019, pp. 619–49.

2.7 Experimental Philosophy and Religion

Interestingly, in the Netherlands it was its connection with religion and not merely natural philosophy that first raised the reading public's consciousness of experimental philosophy. For it is now thought that the publication of Bernard Nieuwentijt's *Het regt gebruik* in 1715 marks an important moment in the awakening to experimental philosophy in Holland.[69] This work was translated into English in 1718 by Peter Chamberlayne as *The Religious Philosopher*, with a prefatory letter to the translator by the leading pedagogue of experimental philosophy in England, John Theophilus Desaguliers. Desaguliers commends the work because: 'it contains several fine Observations and Experiments, which are altogether new, as is also his manner of treating the most common *Phaenomena*; from which he deduces admirable Consequences in favour of a Religious Life'.[70] Likewise, Lambert ten Kate's Dutch adaptation of George Cheyne's *Philosophical Principles of Natural Religion*, published in Amsterdam in 1716, turned experimental philosophy to apologetical use. Kate claims that 'some distinguished men in England, who disliked the uncertainties of hypotheses [of Cartesianism], have based themselves only on a *Philosophia Experimentalis*, by means of mathematics'.[71] He drew a strong connection between Newton's natural philosophy and evidence for God's hand in creation.

This should hardly surprise us, for from the first decade of its existence early modern experimental philosophy in many quarters (though not everywhere, for instance not in Italy[72]) enjoyed an intimate relation with Christianity. This manifested itself in at least two ways. First, experimental philosophy, it was argued, was a great help in the development of the mind and character of the Christian. Second, and later, it came to play a central role in Christian apologetics.

With regard to the first, the relation between experimental philosophy and the life of the Christian, many of the early experimental philosophers were keen to make this connection. From his earliest writings after his turn to natural philosophy, such as his 'Of the Study of the Book of Nature' *c.* 1653,[73] Boyle stressed this feature of natural philosophy. For example, in his 'Of Naturall Philosophie', which pre-dates the emergence of his experimental philosophy, he lists one of two uses of natural philosophy as being 'To excite &

[69] Jorink and Zuidervaart 2012, p. 13.
[70] Nieuwentijt 1718, 1, n.p.
[71] Quoted in Jorink and Zuidervaart 2012, p. 31.
[72] Experimental philosophers in seventeenth-century Italy kept natural philosophy sharply distinct from theological and religious matters, most likely to minimise the risk of being censored by Church authorities, losing the support of patrons, and prompting disputes or smear campaigns from ecclesiastics and Peripatetics. See Vanzo 2019.
[73] B 13 145–72.

entertaine Devotion' (M. Hunter 2000, p. 30). Indeed, it is interesting to see just how the ESD figured in his conception in this regard. In manuscript material for *The Christian Virtuoso*, II that was only published in 1744, he tells us: 'I grant then, that the speculative part of natural philosophy, does *most conduce* to make men admire and praise God's *wisdom*; but the experimental part, may *powerfully engage* them to admire and praise his *goodness*' (B 12 486).

In the following decade, some of the Fellows of the early Royal Society, such as Joseph Glanvill, wrote extensively on the theme of the positive benefits of the practice of experimental philosophy for Christians. See, for example, Glanvill's *Philosophia Pia: or a Discourse of the Religious Temper, and Tendencies of the Experimental Philosophy* (1671).[74] Others such as Thomas Sprat were keen to defend the practice of experimental philosophy as not detrimental to religion. He devotes thirty-three pages to the theme 'Experiments not dangerous to the Christian Religion' in Part III of his *History of the Royal-Society*.[75] Still others, such as Samuel Parker in his *Tentamina de deo* (1665), used the new philosophy to supplement his attack on atheism that drew largely from humanist learning.[76]

Once experimental philosophy had consolidated its position as the predominant new approach to natural philosophy, it began to be used for the purposes of Christian apologetics. In Robert Boyle, experimental philosophers had the archetypal Christian virtuoso who not only manifested the benefits of practising Christianity in his character but also did much to promote the link between the new experimental natural philosophy and the defence of the faith. In *The Christian Virtuoso, I*, Boyle claimed that 'the Experimental Philosophy giving us a more clear discovery . . . of the divine Excellencies display'd in the Fabrick and Conduct of the Universe, and of the Creatures it consists of . . . leads it [the mind] directly to the acknowledgment and adoration of a most Intelligent, Powerful and Benign Author of things' (B 11 293).[77] Boyle's ultimate legacy in this regard was the provision in his will for the Boyle Lectures. And it was the inaugural Boyle Lecturer, Richard Bentley, who first mobilised Newton's new natural philosophy in Christian apologetics in the seventh and eighth lectures of his *The Folly and Unreasonableness of Atheism* (1693), published after extensive correspondence with Newton himself. Once the precedent was established, it was continued and augmented in the early eighteenth century in works such as George Cheyne's *Philosophical Principles of Natural Religion* (1705), William Derham's *Astro-Theology: or a Demonstration of the Being and*

[74] This was no new theme for the apologist Glanvill. See his *Scepsis Scientifica*, Address to the Royal Society, Glanvill 1665.
[75] Sprat 1667, pp. 345–78.
[76] See Levitin 2014b.
[77] See also, for example, Locke, *Essay* IV. xii. 12.

Attributes of God, from a Survey of the Heavens (1715), and William Whiston's *Astronomical Principles of Religion, Natural and Revealed* (1717).[78]

2.8 Experimental Philosophy's Shifting Targets

While some experimental philosophers regarded their new approach to natural philosophy as an antidote against atheism, others seem to have paid no attention to the relation between natural philosophy and religion at all. What they all agreed upon, however, is that experimental philosophy is superior to and should take precedence over speculative philosophy. And yet as the latter decades of the seventeenth century unfolded, the precise targets of their anti-speculative attacks underwent some important changes. Thus, it is too simplistic to see experimental philosophy as uniformly setting itself against Scholasticism or against Epicureanism throughout the period, and it will repay us to spell out in this section the salient changes of the speculative targets that the experimental philosophers attacked.

First, it is worth reiterating that, in the eyes of experimental philosophers, speculative philosophy was a type of philosophy, that is, any philosophy developed from principles with insufficient recourse to observation and experiment. As such, speculative philosophy was not restricted to one philosopher, school, or era. Thus, when the Duchess of Newcastle says in the Preface to her *Observations* that in a previous work she 'had the courage to argue . . . with some famous and eminent writers in speculative philosophy', she is referring to Descartes, Hobbes, and Joan Baptiste van Helmont, each of whom she discusses at length in her *Philosophical Letters* of 1664.[79] Likewise, Boyle in his 'Proëmial Essay' mentions the ancients Leucippus, Epicurus, and Aristotle, and the moderns Telesio and Campanella, as speculative wits. Amongst the chymical physicians, Galenic medicine is frequently classed as speculative,[80] and later in the century Locke lists Descartes, the corpuscularians, and the Peripatetics as producers of speculative systems.[81]

Nevertheless, as the century progressed, there is a discernible trend evident in the polemical engagement of the experimental philosophers with their speculative counterparts. A large proportion of the anti-speculative rhetoric amongst early proponents and promoters of experimental philosophy is focused on Aristotelian natural philosophy. Samuel Parker is typical in his pitting of experimental philosophy against the Aristotelian in 1666: 'The chief reason therefore, why I prefer the

[78] See Anstey 2017b.

[79] Cavendish 2001 [1666/8], p. 10. Interestingly, Cavendish's *Philosophical Letters* of 1664 conveys no awareness of the distinction between experimental and speculative philosophy which provides the terms of reference for her *Observations* two years later. It appears that it was in the years 1664–6 that she became aware of the new experimental philosophy.

[80] See, for example, Starkey 1661, pp. 11–12; Nedham 1665, pp. 237–8 (quoting Willis) and pp. 254–5; Simpson 1669, pp. 205–7.

[81] Locke 1989 [1693], p. 247.

Mechanical and Experimental Philosophie before the *Aristotelean*, is not so much because of its so much greater certainty, but because it puts inquisitive men into a method to attain it, whereas the other serves only to obstruct their industry by amusing them with empty and insignificant Notions' (Parker 1666, p. 45).

From the 1680s, however, the focus shifted to Cartesianism and, in particular, the Cartesian vortex theory. This is not to claim that there were no critics of the speculative nature of Descartes' natural philosophy early on. In fact, William Petty's criticisms of Descartes pre-date the emergence of experimental philosophy altogether.[82] Likewise, there continued to be critics of Aristotelian natural philosophy from within the ranks of experimental philosophers, such as that of William Molyneux quoted in Section 2.3.[83] None of this, however, undermines the claim that there was a shift such that, by the end of the century, Descartes' vortex theory had become the archetypal speculative theory.

A number of developments in the final decades of the century help explain this shift. First, there was the success of the critique of Aristotelian theories of forms and qualities, a critique which, ironically, was partially instigated by Descartes himself. By the 1680s, Aristotelian substantial forms and real qualities and the whole edifice on which the Aristotelian theory of qualities stood had been successfully undermined.[84] Second, from the 1660s there had been a proliferation of speculative Cartesian cosmogonies in the Netherlands, France, and England. These highlighted the highly speculative nature of Descartes' theory of the formation of the Earth and ultimately of his vortex theory of planetary motions. By the early 1680s, sceptical remarks about such Cartesian speculations are in evidence, and following the publication of Newton's *Principia* in 1687, the vortex theory came in for harsh treatment. Christiaan Huygens commented that Newton had 'destroyed' Descartes' fictions, and John Keill in Oxford became a particularly severe critic.[85]

2.9 Who Qualifies as an Experimental Philosopher?

The cases of Rohault and de Volder discussed above (Section 2.6) bring to the fore the question as to what is required for someone in the early modern period to qualify as an experimental philosopher. In fact, Aaron Spink has claimed that Rohault most definitely is an experimental philosopher, appealing to our

[82] See C. Webster 1969, pp. 367–8. For Samuel Parker's criticisms of Descartes, see Parker 1665; Levitin 2014b. For Hooke's criticism of Descartes' failure to experiment, see Hooke 1665, p. 46. For criticisms of Cartesianism in France in the 1670s and 1680s, see Roux 2013b, pp. 77–84.

[83] W. Molyneux 1692, dedicatory epistle, sigs. A1–3.

[84] On the fate of the Aristotelian theories of forms and qualities in the seventeenth century, see Ariew and Grene 1999; Newman 2006; Des Chene 2006, pp. 70–82; Manning 2012; Anstey 2013c.

[85] Huygens 1888–1950, 21, p. 437 and 10, p. 405; Keill 1698, pp. 11–19.

own distinction between an experimenter and an experimental philosopher.[86] It would be most convenient for us if there were an unambiguous set of necessary and sufficient conditions for someone to belong to the class of early modern experimental philosophers. After all, many have argued that one of the real problems with the RED is the failure of its classifications of philosophers as either rationalists or empiricists (see Chapter 8), and a set of unambiguous classificatory criteria for the ESD would be a point in its favour. To that end, we posit four criteria that we might apply: two doctrinal, one occupational, and one temporal. In addition, we suggest that there are qualifying marks or indicators that help identify experimental philosophers.

First, it does seem necessary, though not sufficient, for someone to qualify as an experimental philosopher that they give priority to experiment and observation over reasoning from principles and hypotheses in the quest for a science of nature. Anyone who denied this would not qualify as an experimental philosopher. Of course, the salient point here is the role of experiment; many natural philosophers pre-dating the emergence of experimental philosophy regarded experience as necessary for knowledge of nature, but it is the particular place afforded to experiment that is crucial here. Yet there is also a shift in the notion of experience. Many Aristotelians, for instance, stressed the importance of experience (in the singular) and regarded it as revealing what happens always or for the most part. Experimental philosophers focus on experiences (in the plural), which are experiences of singular events which took place at a specific time and place. If there is room for objection to this criterion it would be in the potential for ambiguity in the notion of experiment and particularly in determining the referents of the French noun *expérience* and the Italian *esperienze*, which were used to designate experiments as well as observations. Here, it is helpful to think of the relation between experiment and observation as a continuum from active intervention on the experimental side to hands-off passive perception on the observational side.[87] Experimental philosophers placed particular emphasis on the intervention side of this continuum.

A second doctrinal criterion is really the obverse of the first, namely, to qualify as an experimental philosopher one must oppose, at least implicitly, the method according to which a science of nature is developed by appeal to principles and hypotheses that are accepted without adequate recourse to experiments and observation. This too is a necessary condition. It is tempting to state this criterion as opposition to speculative philosophy. However, given that there were disciplinary uses of the term 'speculative philosophy', referring to content rather than method, throughout the period, and given that the referent of the term *philosophie speculative* took on an important new meaning in the Berlin Academy of the 1740s (see Section 7.4), we will avoid

[86] Spink 2018, pp. 868–9.
[87] For further discussion, see Anstey 2014a, pp. 105–6.

characterising it in this manner here. Nevertheless, we would resist calling Rohault an experimental philosopher on the grounds that he does not satisfy this criterion for the reasons set out in Section 2.6 above.[88]

A third, occupational criterion, that is necessary though not sufficient, is that the person be a natural philosopher. This criterion begins to highlight the difficulties of classification as an experimental philosopher. For example, by this criterion Joseph Glanvill and Thomas Sprat, two outspoken polemicists in the cause of experimental philosophy and, therefore, in a loose sense, members of the movement, were not experimental philosophers.

Our fourth, temporal, criterion is best stated negatively: there were no experimental philosophers before the emergence of the movement of experimental philosophy. We have argued in this chapter that this movement emerged in the late 1650s and early 1660s in England, and this puts a rough *terminus a quo* on this criterion. Recall that a movement is 'a course or series of actions and endeavours on the part of a group of people working towards a shared goal', and in the case of experimental philosophy, those actions are the performing of experiments and observations, and the shared goal is a science of nature founded on principles that are justified on the basis of experiment and observation.

This temporal criterion requires some elaboration. Almost all socially constructed classes involve some level of indeterminacy or vagueness. A case in point is the loose cluster that has come to be called the Oxford physiologists (see Section 2.1). Who exactly qualifies as a member of this group and on what criteria? We might think that one is that they were domiciled in Oxford, but as Charles Schmitt commented, the Oxford connections of some of those in the group 'are rather tenuous' (Schmitt 1982, p. 432). Turning to our temporal criterion, there is no precise date when the movement of experimental philosophy emerged. And what of the status of, say, Wilkins or Boyle just before the movement began? Were they not experimental philosophers then? And what of those precursors who satisfy the doctrinal and occupational criteria, such as Francis Bacon? The adequacy of our criteria must rest on the explanatory utility of the class that they define and their consistency with the historical record. The fact that the class experimental philosopher is not fully determinate is not a reason for dismissing it, but rather a stimulus for seeking a more nuanced understanding of the historical phenomena.

Let us turn then to marks or indicators that someone may be an experimental philosopher. A first indicator that someone is an experimental philosopher is that they perform experiments. Yet, again, this is neither necessary nor sufficient. There is no doubt that experiments performed in Italy, France, and Germany, as well as England, prior to the emergence of both the explicit method of experimental philosophy and the movement were sources of inspiration. Indeed, in some cases there was a direct continuity between these early

[88] See also Roux 2013b.

experiments and those performed by the first experimental philosophers, but that does not thereby qualify these experimenters as experimental philosophers. Consider Galileo; he seems to oscillate between traditional and innovative understandings of the roles of experiments and observation. He is typical of many natural philosophers in the early seventeenth century who employed experiments but lacked the methodology of experimental philosophy and pre-dated the movement.[89]

A second indicator is that the person concerned self-identifies as a member of the movement. Yet this cannot be a necessary or sufficient condition. Take, for example, the eighteenth-century divine Julius Bate, who wrote a work entitled *Experimental Philosophy Asserted and Defended* (1740). Ostensibly, he identifies himself with the movement, but a close reading of his book reveals that it defends from untested first principles an idiosyncratic form of Cartesianism and is a far cry from a work of experimental philosophy.

In conclusion, we want to stress that our aim in setting out these criteria and marks is not to be overly prescriptive. The historical record is not clear-cut on this matter, and our criteria are guides only. Where they come under pressure from the historical record, as in the cases of Bacon as father of experimental philosophy, Sprat and Glanvill as polemicists for the movement, or Christiaan Huygens, who appears never to have identified with the movement, we use them in order to navigate the complexity of the linguistic, conceptual, and sociological phenomena that make up early modern experimental philosophy as both a natural philosophical method and a movement. The key questions to ask when classifying someone as an experimental philosopher according to any criteria are: What is to be gained by classifying this person as an experimental philosopher? And is this classification consistent with the historical record?

2.10 Conclusion

It is clear then that, by the end of the seventeenth century, the movement of experimental philosophy was well established in England and had spread to Italy. The natural philosophical methodology that characterises the movement was first articulated by Robert Boyle in the late 1650s and was widely adopted by Fellows within the early Royal Society in the early 1660s and by many physicians. As that decade unfolded, critics of experimental philosophy arose, such as Margaret Cavendish, Meric Casaubon, and Henry Stubbe,[90] but the

[89] See Gómez López 2002, pp. 91–7. For an analysis of Galileo's method from the perspective of the ESD, see Dawes 2016.

[90] Stubbe appears to be the only 'turncoat critic' of experimental philosophy, having once been 'passionately addicted to the new Philosophy' (1670a, sig. †3r). In the late 1650s, as one of the Oxford physiologists, Stubbe had translated Boyle's 'Essay of Nitre' into Latin and witnessed the injection of opium into a dog at Boyle's lodgings, 1670a, p. 64 and 1670b, p. 117.

movement developed from strength to strength. And while its polemical targets shifted as the years wore on, its central tenet of prioritising experiment and observation over speculation and hypotheses came more and more to be endorsed as the most viable way to pursue the study of nature. In fact, by the early eighteenth century it was so well entrenched that it began to be used in Christian apologetics. Yet there is one salient feature of seventeenth-century English experimental philosophy that we have not touched on so far, and that is its commitment to natural history. This is the subject of the next chapter.

CHAPTER 3

Experimental Natural History

In the previous chapter, we traced the emergence of early modern experimental philosophy in Oxford in the late 1650s, its development in the early Royal Society of London, and its subsequent spread to the Continent. Yet there is much more to the experimental philosophy of this period than we have discussed so far. Any careful reader of the writings of experimental philosophers from the 1660s will soon notice a recurring theme, namely, natural history.

It had long been appreciated that natural history was an important component in Francis Bacon's grand instauration of knowledge. Descartes, for example, wrote to Mersenne on 10 May 1632 that he wished that someone dedicated to the advancement of the sciences would 'undertake to write a history of celestial appearances according to the method of Verulam [Bacon]' (Descartes 1996, 1, p. 251), that is, with exact descriptions without any reasons or hypotheses.[1] As we saw in Chapter 1, John Johnston also refers to Bacon's innovations in the realm of natural history in the 1630s. Moreover, there are occasional references to Bacon's project for natural history among the Hartlib Papers.[2] Indeed, by the mid-1660s many had come to define the overall project of natural philosophy in terms of constructing a universal natural history. Thus, in the passage we cited from the *Saggi* of the Accademia del Cimento we find a reference to such a project: 'We are unwilling any should imagine, That we pretend in this Publication, a Perfect Work; or in the least, an Exact Module of a large *Experimental History*; conscious to our selves, that more Time, and greater Abilities are necessary to so vast a Design' (Waller 1684, sig. b2^{v}).

In Paris in 1663, before the establishment of the Académie des Sciences, Christiaan Huygens put forward a 'Project de la Compagnie des Sciences et des Arts'.[3] This document bears many parallels with similar recommendations that were being formulated across the Channel for the Royal Society of London and may well have been influenced by the views of Sir Robert Moray with whom Huygens was corresponding at the time.[4] Huygens presents a grand

[1] On the relation between Descartes' method of experimentation in his *Meteorology* and that of Bacon, see Georgescu and Giurgea 2012.
[2] See, for example, Hartlib Papers, 28/2/5B, 29/3/9B, 29/6/10A, and 41/1/99A.
[3] For further discussion, see Roux 2013b.
[4] See Hunter and Wood 1989, pp. 247–8.

vision of a scientific society that is conceived in terms of what can only be described as a Baconian natural history:

> The company will entertain commerce with all the other academies and with all scientists of every country so as to reciprocally instruct one another on that which is particular in nature and the arts and that which is new touching books and the sciences, and to observe by this means all places, seasons, the winds, the hottest, the coldest . . . eclipses, comets, meteors . . . by the use of thermometers . . . of pendulums and all the other instruments necessary for enabling the making of a history of nature as universal as possible, on which as on a solid foundation, one can work to establish a natural philosophy and similarly a history of arts and of the inventions of men. (Huygens 1888–1950, 4, p. 327)

There is no doubt that this is a Baconian conception and that Huygens, in articulating the role of natural history as a foundation on which to build a solid natural philosophy, is at the same time laying down part of the methodological foundation on which the Académie would eventually be established. His later recommendation to Colbert is even more explicit:

> The principal occupation of this assembly and the most useful must be, in my opinion, to work towards a natural history more or less following the design of Verulam. This history consists in experiments and remarks and is the unique method for arriving at an understanding of the causes of all that we see in nature. . . . such a history . . . is always a sure foundation on which to base natural philosophy. (Huygens 1888–1950, 6, pp. 95–6; see also 19, p. 268)

It was among the Fellows of the Royal Society of London, however, that this approach to natural philosophy really took hold and was developed, refined, and put into practice. We get an early insight into this in 1665, in the eighth issue of the *Philosophical Transactions*. There, Henry Oldenburg, the secretary of the Royal Society, encapsulated the method of the new Society with the following words: 'It being the Design of the R[oyal] Society, for the better attaining the End of their Institution, to study *Nature* rather than *Books*, and from the Observations, made of the *Phaenomena* and Effects she presents, to compose such a History of Her, as may hereafter serve to build a Solid and Useful Philosophy upon' (Oldenburg 1666a, pp. 140–1).[5] This is one of many such statements to be found in the *Transactions* and in Oldenburg's correspondence.[6] These statements show, as do the *Transactions* themselves, that one of the leading ways in which natural philosophy was conceived and practised in the early Royal Society was as a programme of natural history. A similar sentiment is found in a passage from

[5] See also the prefatory remarks by Oldenburg to Boyle's 'General heads for a natural history of a countrey', B 5 508, which refer back to this comment, and B 5 299.

[6] See, for example, 'Enquiries concerning agriculture', *Philosophical Transactions*, 1.5, p. 91 and *Oldenburg Corr.*, 2, pp. 141–4; 3, pp. 73–8, 87, 193, 216–19; 8, p. 307.

Samuel Parker from his *Free and Impartial Censure of the Platonick Philosophie* of 1666 that follows on from the one we cited in the previous chapter:

> having discarded all particular *Hypotheses*, and wholly addicted themselves to exact Experiments and Observations, they [the Fellows of the Royal Society] may not only furnish the World with a compleat *History of Nature*, (which is the most useful part of *Physiologie*) but also laye firm and solid foundations to erect *Hypotheses* upon, (though perhaps that must be the work of future Ages:) at least we shall see whether it be possible to frame any certain *Hypotheses* or no, which is the thing I most doubt of, because, though the *Experiments* be exact and certain, yet their Application to any *Hypotheses* is doubtful and uncertain; so that though the *Hypothesis* may have a firm *Basis* to bottome upon, yet it can be fastned and cemented to it no other way, but by conjecture and uncertaine (though probable) applications, and therefore I doubt not but we must at last rest satisfied with true and exact Histories of Nature for use and practice; and with the handsomest and most probable *Hypotheses* for delight and Ornament.
>
> (Parker 1666, pp. 45–6)

In this chapter we argue that the first generation of experimental philosophers developed and applied a new form of natural history, Baconian natural history, and that this became the primary – though not the only – method by which experimental philosophy was practised from the 1660s in Britain. Surprisingly, however, this form of natural history began to go into decline in the 1690s and was eventually eclipsed by a seemingly more promising form of experimental philosophy.

After sketching our historiography of early modern natural history in Section 3.1, we examine the importance of experiment in this new form of experimental natural history in Section 3.2. Then, in Section 3.3 we set out the leading philosophy of experiment that accompanied this new form of natural history and which provided some of the categories for experimental practice in Britain in the latter decades of the seventeenth century. In Section 3.4, we show just how widely practised this approach to natural history was amongst Fellows of the Royal Society and their correspondents. Section 3.5 documents and attempts to explain the demise of experimental natural history in the final decade of the seventeenth century.

3.1 The Historiography of Early Modern Natural History

The history of natural history is a complicated matter, not least because the terms 'natural history' and *historia* were used to refer to a variety of different subject matters, practices, and genres.[7] This is particularly true of the natural history of

[7] On the meanings of 'historia' in the Renaissance and early modern periods, see Pomata and Siraisi 2005. For further discussion of the historiography of early modern natural history, see Anstey and Jalobeanu 2022, pp. 223–9.

the early modern period. In order to understand the discipline, or disciplines, of natural history, we need to begin with a provisional classification.

Natural history is a very old discipline, stretching back to antiquity in the works of Aristotle, Theophrastus, Pliny the Elder, Dioscorides, and others. It underwent a revival in the fifteenth and sixteenth centuries at the hands of the likes of Leonhart Fuchs (1501–66), Ulisse Aldrovandi (1522–1605), and Conrad Gessner (1516–65). In some respects, this Renaissance natural history has continuity with the natural history of Pliny and other ancients, though in many ways it emerged as a new discipline.[8] In our view, it is helpful to distinguish three different forms of natural history that span the Renaissance and the early modern period: Renaissance natural history, classificatory natural history, and Baconian or experimental natural history.

If Brian Ogilvie's analysis is correct, two very important developments took place in natural history towards the end of the Renaissance period. First, the sheer number of different natural kinds that had been discovered by the end of the sixteenth century exceeded anyone's ability to memorise or even manage a single complete natural history. And second, as a result of this proliferation of species and other developments, such as the Ramist theory of division, some natural historians, such as Andrea Cesalpino and Adam Zaluziansky, sought taxonomic schemes by which to order and arrange the plethora of species. Thus, Renaissance natural history did not become a classificatory discipline until the very end of the sixteenth century; it was not concerned with uncovering a 'natural system'.[9] For this reason, Ogilvie aptly calls it the science of describing: it was a descriptive and not a classificatory science that predominated in the period before the seventeenth century. Thus, we will use the term 'Renaissance natural history' and its synonym 'the science of describing' to refer to natural history of the fifteenth and sixteenth centuries as practised by Gessner, Aldrovandi, and others.

It should be added, because it is relevant to later concerns of this chapter, that there were other genres that were described as natural history in addition to those that are normally included under the banner of Renaissance natural history. For example, there are the histories of countries and regions such as José de Acosta's *Historia natural y moral de las Indias*, first published in Seville in 1590. However, when the early moderns refer to the natural history of the previous two centuries, they more often than not are referring to the science of describing. For example, when in the early seventeenth century Francis Bacon came to critique the recent revival of natural history, it was primarily the science of describing that he had in view.[10]

[8] This is the central thesis of Ogilvie 2006. For the humanist critique of Pliny, see Ogilvie 2006, pp. 121–31.

[9] Ogilvie 2006, pp. 221–9.

[10] See Jalobeanu 2015, chapter 2 for a discussion of parallels between Bacon and other forms of late sixteenth-century natural history.

The science of describing, that is, the dominant form of natural history practised in the Renaissance, continued in the seventeenth century, though now encumbered with an ever-increasing subject matter and a self-conscious quest for the definitive taxonomic system. It features in the work of, say, the botanists Robert Morison (1620–83) and John Ray (1627–1705) in England, and Pierre Magnol (1638–1715) and Joseph Pitton de Tournefort (1656–1708) in France.

We will use the term 'classificatory natural history' to refer to the practice of natural history in the seventeenth and eighteenth centuries that was continuous with Renaissance natural history insofar as it aimed at describing natural kinds, but with this difference, that in many cases it also came to involve taxonomic schemata and theoretical reflection upon the nature of species. Thus, classificatory natural history was the early modern manifestation of Renaissance natural history, but with the additional focus on classification.

Brian Ogilvie has made the interesting observation that most seventeenth-century works of (what we call) classificatory natural history do not use the term 'historia naturalia' or 'natural history' in their titles; instead, they simply use the term 'historia'.[11] A nice set of examples are the histories of the arch-rivals Robert Morison and John Ray. Morison (and Jacob Bobart the Younger) published a multi-volume *Plantarum historiae* and Ray a three-volume *Historia plantarum*, but neither botanist used the term *historia naturalis* in their titles.[12]

The following crude statistics from Early English Books Online bear out Ogilive's point. Nearly fifty books in English were published in Britain between 1660 and 1700 with the term 'natural history' in their title. Three-quarters of these books are products of or are related to Baconian natural history. These include six reissues of Bacon's *Sylva Sylvarum* (popularly known as Bacon's Natural History); six works by Boyle; fifteen county histories; Woodward's *Natural History of the Earth* (1695) and John Harris' defence of it (1697); Walter Charleton's *Natural History of the Passions* (1674); and William Clarke's *Natural History of Nitre* (1670).[13]

The list also includes two issues of an epitome of Bacon's *Novum organum*, and it is worth pausing to examine the title page of this work: *The Novum organum of Sir Francis Bacon, Baron of Verulam, Viscount St. Albans epitomiz'd, for a clearer Understanding of his Natural History*, London, 1676 and 1677. This short volume of select aphorisms drawn from the *Novum organum* contains material explicitly selected 'for a clearer understanding of his natural history'. It contains twelve references to natural history, including two uses of

[11] Ogilvie 2005, pp. 82 and 98.
[12] Morison 1669, 1680, and 1699; Ray 1686, 1688, and 1704.
[13] Woodward 1695; Harris 1697; Charleton 1674; W. Clarke 1670. For Clarke's references to Bacon, see W. Clarke 1670, pp. 37 and 91.

the term 'Natural and Experimental History' (p. 22) in its thirty-two pages. The volume was reprinted a year after its first issue.

Another volume that appears in this list is entitled *General heads for the natural history of a country great or small drawn out for the use of travellers and navigators imparted by . . . Robert Boyle . . . ; to which is added, other directions for navigators, etc. with particular observations of the most noted countries in the world; by another hand*, London, which appeared in 1692. This work, published the year after Boyle's death, contains a reprint of Boyle's original and very influential *Philosophical Transactions* article of 1666 augmented by much additional material. In fact, Boyle most likely had nothing to do with this volume, and it was an attempt by his printer John Taylor to cash in on 'The English Philosopher's' posthumous reputation.[14] Its publication, however, bears testimony to the interest that the Baconian method of natural history retained into the early 1690s. Boyle did, however, sanction the publication of one posthumous work that appeared in 1692. This was his *General History of the Air*, which was seen through the press by John Locke and is the final instalment in his three-decade project of constructing a natural history of the air. This work was not among Early English Books Online's's list of fifty-odd books because it lacks the term 'natural' in its title.

Of those books that use the term 'natural history', there are two that are histories of particular animals: Jan Swammerdam's *Ephemeri vita, or, The Natural History and Anatomy of the Ephemeron, a Fly that Lives but Five Hours*, London, 1681 and Edward Tyson's *Phocaena, or The Anatomy of a porpess*, London, 1680. Swammerdam's and Tyson's works are detailed anatomical studies of particular species. That leaves Thomas Vaughan's *A Brief Natural History Intermixed with Variety of Philosophical Discourses; and Observations of the Burning of Mount Ætna*, 1669. Vaughan's slightly eccentric book seems to be called a natural history after the example of Pliny the Elder and does not, to our knowledge, integrate with an existing genre or practice of natural history writing. In sum, Ogilvie's observation about the use of the term 'natural history' is borne out by English-language texts: they are largely the province of Baconian natural history.

We will use the terms 'Baconian natural history' and 'experimental natural history' to refer to the sort of natural history that was theorised and practised by Francis Bacon and his heirs in the seventeenth and early eighteenth centuries. Francis Bacon was a harsh critic of ancient and Renaissance natural historians and their histories. He attacks their aims, their content, and their literary style.[15] The precise nature of his criticisms need not detain us here,

[14] See Michael Hunter's discussion in the appendix to the introductory notes in B 6 xli–xlv.
[15] These attacks have been ably summarised in Graham Rees 'Introduction' to OFB 12 xix–xxxiii.

except to say that they were repeated by Robert Boyle and Robert Hooke in the second half of the seventeenth century.[16]

In place of Renaissance natural history, Bacon proposed his own sophisticated form of natural history. It is difficult to overemphasise the importance that natural history played in Bacon's mature presentation of his great instauration of knowledge.[17] Indeed, the project of articulating the method of and construction of natural histories came to dominate the last years of his life. It is helpful to characterise it as having four strands.

1. The manner in which it was integrated into his scheme for the sciences in *The Advancement of Learning* and then, with important developments, in *De augmentis scientiarum*. Of particular importance here is its relation to his theory of *experientia literata* and *interpretatio naturae* and thus to his accounts of experiment, induction, and natural philosophy.[18]
2. The content and method of the theory comprises the arrangement of subjects that histories are to include and the method of their construction.
3. Bacon's own speculative natural philosophy.
4. Bacon's own exemplar histories, histories that served various purposes and which had different motivations.[19]

In the seventeenth century, many natural philosophers took up the *content* and *method* of Bacon's theory of natural history, and some were inspired by and sought to emulate or even extend his *exemplar natural histories*,[20] but, to our knowledge, there is little evidence that his account of the classification of

[16] See Boyle's 'De Imperfectione Historiae Naturalis' and 'Of the Insufficiency of Natural History' in Boyle 2008 [1666], pp. 8–10 and 11. For Hooke's criticisms of the current state of natural history, see his 'Requisites' (Oldroyd 1987, p. 151) and *General Scheme* (Hooke 1705b, pp. 3–4 and 21).

[17] 'My *Organum*, even if it were finished, would not carry forward the Instauration of the Sciences much without Natural History, whereas Natural History without the *Organum* would advance it not a little', *Natural and Experimental History*, OFB 12 13.

[18] On the classification of natural history among the sciences, see Anstey 2012. On *experientia literata*, see Jalobeanu 2015, chapter 6. On *interpretatio naturae*, see Serjeantson 2014.

[19] The situation with Bacon's own Latin natural histories is rather complicated because of their links to the third strand, namely, his own speculative natural philosophy.

[20] See, for example, Austen 1658, which addresses a small selection of experiments from Bacon's *Sylva Sylvarum*. For commentary, see Matei 2017. Ralph Bohun (1671) extends Bacon's *History of Winds*. See also Halley 1687. John Graunt relates his work on bills of mortality (1662) to Bacon's *History of Life and Death*. Likewise, Boyle regarded his work as continuous with that of Bacon, even structuring his observations in the Baconian manner:

> many of the Particulars which we are now considering, were in my first Design collected in order to a Continuation of the Lord *Verulam's Sylva Sylvarum*, or Natural History. And that my intended Centuries might resemble his, to which they were to be annex'd, it was requisite that such kind of Experiments and Observations as we have been newly speaking of, should make up a considerable part of them. (B 2 17)

natural history and his own speculative natural philosophy exerted much influence.[21] Thus, when we speak hereinafter of Baconian natural history, we refer primarily to the Baconian account of the content and method of natural history and only tangentially to Bacon's own determinate natural histories. Baconian natural history as it was theorised and practised in the seventeenth century was, therefore, a somewhat truncated form of what its progenitor had envisaged.

It will be helpful at this point to clarify the relation between experimental natural history and classificatory natural history. In the first place, this relation was one of overlap. Since Bacon's project was an architectonic programme for the whole of natural philosophy, it naturally subsumed the practice of describing and classifying natural kinds. Yet the relation between the two approaches is not as simple as a part–whole relation. This is brought out nicely in what is perhaps Boyle's most succinct statement of the purpose of natural history:

> [Its] role consists not so much in showing us the variety of natural things arising of their own accord, as in rendering an exact account of the more instructive phenomena of nature left to herself, and especially of those others which, established outside her common order, she is forced to produce by the skill and industry of men. Phenomena of this kind are highly conducive to the two aims of a philosophical natural history, of which one is to teach us how we are to explain not just the usual phenomena that nature displays as though of her own accord, but also those where art co-operates (and perhaps predominates), and then how a knowledge of natural causes may come to be applied to producing effects of use in this life. ('De imperfectione Historiae Naturalis', B 13 359)

Boyle's reference to 'the variety of natural things arising of their own accord' is an allusion to the subject matter of classificatory natural history. He is claiming here that instead of merely cataloguing and describing natural things that arise 'of their own accord', natural history concerns not only those phenomena 'of nature left to herself' but especially 'those others which, established outside her common order, she is forced to produce by the skill and industry of men'. The reason for this is that it is these phenomena that help us to achieve the aims of true natural philosophy, viz. to explain natural phenomena and to provide knowledge of causes with a view to producing useful effects.

As a consequence of this, the natural history that Boyle and his fellow Baconians developed differed markedly from classificatory natural history in the range of its subject matter, in its methods of extracting and arranging knowledge, and in its relation to the various sub-disciplines within natural philosophy. Classificatory natural history was largely restricted to the study of what are now called natural kinds. Baconian natural history, by contrast, had

[21] Francis Glisson (1672) and Ralph Austen (1665) did take up aspects of Bacon's speculative matter theory. On Austen, see Matei 2018.

a threefold subject matter of generations (including natural kinds, but much more besides), pretergenerations, and arts. The range of what is included in generations can be captured from Bacon's *Parasceve* or Hooke's *General Scheme*. They include virtually everything from the heavens to the centre of the Earth (as we see in Hooke's histories of earthquakes and fossils),[22] and the sea and even, in Boyle's case, the seabed. Only a tiny fraction of this came within the remit of classificatory natural history.

Another way to capture the difference in scope between classificatory and Baconian natural history is to set things up in terms of the treatment of the qualities and states of matter. According to the hegemonic Aristotelian natural philosophy, the primary material qualities are the *explanans* of all other qualities and the elements. Thus, the *primae qualitates* of hot/cold and wet/dry explained the secondary qualities heavy/light and dense/rare as well as the four elements earth, air, fire, and water.

By contrast, the new mechanical theory of qualities adopted and developed by Boyle turned the Aristotelian *explanans* into the *explananda*: rather than doing the explaining, hot/cold and wet/dry were now to be explained using the mechanical, or what Locke later called the primary qualities of matter. Thus the Aristotelian *primae qualitates* were now themselves ripe as subjects of natural history. Bacon, famously, had given a provisional natural history of heat in Book Two of the *Novum organum*, so Boyle provided a natural history of cold.[23] Wet and dry were now seen to be states of bodies rather than primitive qualities in their own right, and Boyle provided histories of fluidity and firmness.[24] As for the Aristotelian secondaries, Bacon wrote a history of dense and rare, and both he and Boyle did extensive work on relative weights – though in the corpuscular theory of Boyle, these were conceived as qualities of bodies, and it was the bodies themselves that now came in for natural histories. We need only instance the multiple instalments of Boyle's history of the air and his histories of mineral waters, gems, and human blood to fill out the picture.[25] None of these were subjects of classificatory natural histories, which remained wedded to the description and classification of biological kinds such as plants and animals.

[22] In the mid-1670s, John Webster spoke of the study of fossils as part of experimental philosophy. See Webster to Lister, 9 October 1674, Lister 2015, p. 728.

[23] Boyle, *New Experiments and Observations Touching Cold, or An Experimental History of Cold Begun*, 1665 in B 4 203–575. For the mechanical theory of qualities, see Anstey 2013c.

[24] Boyle, 'The History of Fluidity and Firmness', 1661, B 2 115–203.

[25] For the first and last instalments of Boyle's history of air, see *Spring of the Air*, 1660, B 1 141–306 and *General History of the Air*, 1692, B 12 3–159; for mineral waters, see *Short Memoirs for the Natural Experimental History of Mineral Waters*, B 10 205–50; for gems, see *An Essay about the Origin and Virtues of Gems*, 1672, B 7 3–72; for human blood, see *Memoirs for the Natural History of Human Blood*, 1684, B 10 1–101. In *Forms and Qualities*, Boyle claims that some mathematicians had provided a natural history of sounds (B 5 299), and he may have had Mersenne in mind. See Dear 1988, chapter 6.

A further example is Boyle's own understanding of his work in chymistry. He informs an unidentified correspondent that:

> I cultivated Chymistry not so much for itself, as for the sake of Natural Philosophy, & in order to it; so most of the Experiments I devis'd & pursu'd, were generally such as tended not to multiply Chymical Processes or gain the Reputation of having store of difficult & Elaborate ones; but to serve for Foundations, & other useful Materials for an Experimental History of Nature; on which a solid Theory may in process of time be superstructed. (B 12 365)

Here in a classic statement of the Baconian method of natural history, Boyle tells his correspondent that the whole purpose of his practice of chymistry was to provide materials for 'an Experimental History of Nature' which in time would provide the true basis for natural philosophy. More could be said about other sub-disciplines of natural philosophy and their relations to Baconian natural history, but space precludes a thorough survey here.[26] Instead, we need to turn to an important, yet underappreciated, feature of Baconian natural history, namely, its relation to geography.

A natural concomitant to its vastly extended scope was that Baconian natural history had a radically different relation to the various sub-disciplines and cognate disciplines of natural philosophy. All forms of natural philosophy, including botany, geology, mechanics, and chemistry, were capable of subsumption under the Baconian rubric. Even in medicine, a discipline often taken to be subaltern to natural philosophy, a new movement emerged that involved the construction of not merely case histories, but natural histories of disease.[27]

Another discipline that was naturally subsumed under the Baconian rubric was geography. The nineteenth title in Bacon's *Parasceve* was: '19. Geographical natural history: of mountains, valleys, woods, plains, sands, fens, lakes, rivers, torrents, springs, and every kind of gushing up belonging to them, and the like, leaving aside peoples, provinces, cities and other aspects of political geography' (OFB 11 477). One popular way of dividing the discipline of geography was found in Bernard Varenius' *Geographia generalis* of 1650. Varenius distinguished between general, special, and chorographic geography. Boyle was a close reader of Varenius' *Geographia*, citing it in a number of works.[28] It is of great interest, therefore, that the heads in his 'General Heads for a Natural History of a Countrey', which was to become

[26] Thus, for example, Jalobeanu and Matei (2020) describe a tradition of experimental natural histories of vegetation that spans from Bacon, via John Evelyn (1676) and Nehemiah Grew (1678), to John Woodward (1695).

[27] See, for example, Sydenham, 'On dropsy', in Sydenham 1848, 1, pp. 12–16; 1991, 97; and T. Molyneux 1694.

[28] See, for example, *Spring of the Air*, B 1 214, 248, 286. See also Boyle's *Hidden Qualities*, B 8 139–40; *Languid Motion*, B 10 275.

emblematic of the Baconian style of the Royal Society's approach to natural history, correspond closely with the *desiderata* recommended by Varenius for special geography (see Table 3.1, overlapping heads are in bold; bracketed numbers in the right column correspond to numbers in the left column).

It seems highly likely, therefore, that Boyle, whether consciously or not, has simply reconceived Varenius' geographical project in terms of

Table 3.1 *Varenius' heads for special geography and Boyle's heads for a natural history of a country*

Bernhardus Varenius: *Geographia generalis*, 1650, pp. 3–4	Robert Boyle: 'General Heads for a natural history of a countrey, great or small', 1666
Celestial	***Supraterraneous***
1. Elevation of the pole	1. **Longitude and latitude (18)**
2. **The obliquity of the diurnal motion of the stars above the horizon from that place**	2. **Length of longest days and nights (3)**
3. **The longest and shortest days**	3. **Climate (4)**
4. **The climate and zone**	4. **Parallels, what stars are and are not seen there (6)**
5. **The heat, cold, and annual temperatures: rains, snow, winds and other weather**	5. What stellar constellations subject to
	The air
6. **The rising of stars, appearance and staying above the horizon**	6. **Temperature (5)**
7. The stars passing through the vertex of the place	7. Measures of first four qualities: **hot, cold**, wet, dry **(5)**
8. The quantity or speed of their motion according to the Copernican hypothesis	8. Weight, clearness, refractive power
	9. Subtlety, grossness, quantity of Esurine salt
	10. Seasonal variations
	11. **Weather (5)**
	12. **Winds (5)**
	13. Epidemic diseases: the plague, contagious sicknesses
	14. Salubrity and insalubrity
	15. Constitutions
Terrestrial	***Terrestrial***
9. **Limits and boundary**	*The water*
10. **Figure**	16. **The sea**: depth, degree of saltness, tides, currents (13)
11. **Magnitude**	

Table 3.1 *(cont.)*

Bernhardus Varenius: *Geographia generalis*, 1650, pp. 3–4	Robert Boyle: 'General Heads for a natural history of a countrey, great or small', 1666
12. **Mountains** 13. **Waters: rivers, springs, seas** 14. **Forests** and deserts 15. **Fertility, sterility and fruits** 16. **Minerals** or fossils 17. **Animals** 18. **Longitude and situation**	17. **Rivers**: bigness, length, course, inundations, goodness, levity of waters, etc (13) 18. **Lakes, ponds, springs**, esp. mineral waters: kinds, store, bigness, goodness (13) *The earth* 19. Its productions, both internal and external 20. **Dimensions (9)** 21. **Figure (10)** 22. Plains and valleys 23. **Hills and mountains: height of the tallest (12)** 24. Promontories, fiery or smoky hills 25. Coherence: islands 26. Magnetical declination: variations 27. Nature of the soil: clay, sandy, etc. 28. Arts & industries to improve soils 29. Soils: hidden qualities 30. **Earth's productions: grasses, grains, herbs, flowers, fruit trees, woods, forests (14)** 31. **Minerals**: coal, salt mines, sulphur . . . (16) 32. Mines: number, situation, depth, waters, damps, quantities of ore . . . 33. **Animals**: wild beasts, hawks, poultry, cattle (17)

experimental natural history. In fact, Benjamin Worsley had explicitly made the connection as early as 1657.[29] Once Varenius' conception of geography

[29] Hartlib records in his *Ephemerides*: 'Varenius or Vaningius Geography Dr Worsl*ey* com*m*ends as one of the best that ever hath beene written for a true Method to make

was subsumed under the Baconian rubric in Britain, it flourished, with natural historical observations of countries and sets of queries proliferating in the *Philosophical Transactions* and other publications. The Restoration period witnessed a burgeoning of interest in what Varenius called special geography, though it was construed as contributions to the architectonic project of experimental natural history.[30] Richard Blome's *Gentlemans Recreation* of 1686 reveals the extent to which it had become part of the popularisation of science later in the century. In his preface, he regards general (universal) and special geography as constitutive of natural history: 'the *Natural History* of the World ... is either *Universal*, and is termed *Cosmography*, being the Description of the *World*; or Special' (Blome 1686, sig. a3).

Another approach to geography, popular in the late Renaissance in England, was to divide it into mathematical, descriptive, and chorographic branches.[31] Bacon's prescriptions for natural history incorporate each of these divisions. The earliest attempt to write chorography as a new experimental history was probably Gerard Boate's posthumous *Irelands Naturall History* (1657), though the first explicit Baconian project in chorography was Joshua Childrey's *Britannia Baconica: or, The Natural Rarities of England, Scotland, & Wales According as they are to be found in every Shire. Historically related, according to the Precepts of the Lord Bacon* of 1660.

Chorography was incorporated into the project for experimental natural history in England from the early 1660s on. To be sure, British chorography had independent origins from the Baconian project, being pioneered by William Camden and others in the late sixteenth century,[32] yet it was very successfully and self-consciously recast in accordance with the Baconian programme.[33] The works of Robert Plot and others became an important constituent of the overall project from the 1670s. Plot's *The Natural History of Oxford-Shire* (1677) was explicitly structured around Bacon's tripartite division of natural history into generations, pretergenerations, and arts 'which ... may fall under the general notation of *a Natural History* ... (as the

a most compleat worke of it it being Geographical and Natural History together. Mr Worsley', Hartlib Papers, 29/6/4A.

[30] That Margarita Bowen (1981, p. 102) could speak of 'the deterioration of geographic thought during the Restoration period in England' is, in our view, evidence of the success of the extent to which proponents of Baconian natural history were able to monopolise the field. Bowen's analysis completely missed the connection between geography and natural history.

[31] See Cormack 1991.

[32] See Camden 1586. On Camden's *Britannia* as a collaborative project, see Vine 2010, chapter 3.

[33] See, for example, Hooke 1661, p. 37.

Lord *Bacon* well observeth)' (Plot 1677, p. 1).[34] The reviewer of Plot's book in the *Philosophical Transactions* regarded it as:

> an attempt so considerable, that if it were pursued by fit persons all over the World with care, judgment and diligence, [it] would in time produce a just *History of Nature*, and furnish both the Philosopher with good Materials to work with, and generally all sorts of men with the pleasant and useful knowledge of the riches and wonders of the World.
>
> (Anon. 1677, p. 875)

Of the other branches of geography, the mathematical and the descriptive, the former made large strides in the latter decades of the seventeenth century, particularly in the field that we now call geodesics. Unlike chorography and descriptive geography, mathematical geography involved new instruments and, most importantly, experiments. And it is the experimental side of Baconian natural history that ties it most intimately to experimental philosophy.

3.2 Experimental Natural History and Experiment

There is a curious footnote in the preface to the second section of Robert Boyle's *Origin of Forms and Qualities* of 1666. In it, Boyle refers the reader to a document 'Containing some Advices and Directions for the writing of an Experimental Natural History' (B 5 392). What according to Boyle is an experimental natural history, and to which document is he referring?

It is almost certain that this is a reference to Boyle's 'Designe about Natural History', parts of which survive in a letter to Henry Oldenburg and in miscellaneous fragments among the Royal Society Boyle Papers.[35] Whether or not Oldenburg ever received the letter, it is clear from the early volumes of the *Philosophical Transactions* that he understood and entirely acquiesced in Boyle's conception of experimental natural history. For, in his editorial preface to the first issue in the fifth year of the journal, 1669, Oldenburg tells us:

> In the *first* Volume, containing the Transactions of *Two* Years, 1665, 1666 ... we then made an Attempt of laying some Foundation for the Improvement of real Philosophy, and for the spreading of Useful knowledge in publishing Advices and Directions for the writing of an

[34] This is acknowledged in the review of the work in the *Philosophical Transactions*, Anon. 1677, p. 876. For Plot's use of queries, see his pamphlet entitled *Quar's to be Propounded to the Most Ingenious of each County in my Travels through England*, Plot 1674. For another example of the Baconian approach to chorography, see Aubrey's *The Natural History of Wiltshire* of 1685 (Aubrey 1847).

[35] See Boyle 2008 [1666]. In *c.* 1665 Boyle listed a work entitled 'Of the compileing of a Naturall History' among his 'The Order of my Severall Treatises' (B 14 331). It is likely that this is equivalent to his 'Designe'.

> Experimental Natural History; in pointing out Essays, Patterns and Exemplars, that have hitherto been designed in that kind; in giving notice of divers Artificial Engins and Instruments, which may be helpful for the further Discoveries of *Nature*, or for the greater performances of *Art*.
>
> (Oldenburg 1669, pp. 893–4)

What is important about the content of this preface is not so much the appearance of the term 'experimental natural history', but the fact that Oldenburg regards the first five years of the *Philosophical Transactions* as being given over to the promotion and development of such a project. For example, in its first two years he intentionally published 'Essays, Patterns and Exemplars' designed for the enterprise as well as descriptions of instruments and engines. Even a cursory perusal of the early issues of the journal confirms that this is indeed the case.

Interestingly, around the very time that Boyle penned his 'Designe' for an experimental natural history, Robert Hooke, the Curator of Experiments at the Royal Society, was writing his own 'Lectures of Things Requisite to a Natural History'. Oldenburg knew of both works and expressed his desire to Boyle that 'both yours and his were publick, considering the great good, it would doe to Philosophy; most men not knowing, what to inquire after, and how' (*Oldenburg Corr.*, 3, p. 33). Hooke's 'Things Requisite' bears striking similarities with Boyle's 'Designe'. It is, in fact, an adumbration of Hooke's *A General Scheme, or Idea of the Present State of Natural Philosophy*, which also bears parallels with Boyle's 'Designe', not least the fact that both documents refer to a philosophical algebra which appears to function as a replacement for Bacon's inductive method (though the details are sketchy).[36] In his 'Things Requisite', Hooke opens with a lament for the current state of natural philosophy and regards the corrective to be the establishment of a 'Naturall and Experimentall history' (Oldroyd 1987, p. 151) Clearly Hooke, Oldenburg, and Boyle shared a common conception of the task of natural philosophy, and we need not even grasp the details of this conception before it becomes apparent that the role of experiment is integral to it.

Of course, Hooke's term 'natural and experimental history' derives from Bacon, first appearing in the latter's *Parasceve* (1620), which opens with a 'Descriptio Historiae Naturalis, et Experimentalis' (Description of a Natural and Experimental History). It then appeared in the title of the influential *Historia naturalis et experimentalis ad condendam philosophiam* (the *Natural and Experimental History for the Building Up of Philosophy*, 1622).[37] Thus, even before examining the contents of any of their publications, it is clear that for Bacon, Boyle, Hooke, and Oldenburg there was a very close relation between natural history and experiment. How then was that relation construed?

[36] For further discussion, see Anstey and Hunter 2008, pp. 117–18.

[37] See OFB 11 450/1, OFB 12 2/3. For Boyle's use of the term 'natural and experimental history', see *Gems*, B 7 9.

According to the prescriptions of the great Verulam, experiments were essential constituents of any natural history. Bacon's *Parasceve* sets out the importance of experiment, and his *Natural and Experimental History* sets out the rules or directions for proceeding in the construction of an experimental natural history. As we noted above (Section 3.1), in the *Parasceve* he tells us that natural history has three parts: generations, pretergenerations, and arts. If we have these three things, 'we will lack nothing we need to equip the sense for informing the intellect'. Of these parts, 'the most useful is the *History of Arts* because it displays things in motion and leads more directly to practice' and strips back the veil from natural things (OFB 11 463).

Bacon's *Natural and Experimental History* of 1622 then applies this to the construction of histories: 'Although at the end of the published part of my *Organum* I drew up precepts concerning the *Natural and Experimental History*, I nevertheless think it right to describe accurately and succinctly the rule and make-up of the history which I now attempt' (OFB 12 13). In the construction of a natural history:

> History and experiments take first place (*omino primas partes tenent*). . . . Since I very often lack history and experiments, especially luciferous experiments and crucial instances which can inform the mind about the true causes of things, I give directions for new experiments suitable . . . for the subject under inquiry. . . . I explain the ways of performing any subtler experiment in case it is flawed, and also so as to prompt others to work out better ways. . . . I append my observations on the history and experiments so as to make the interpretation of nature readier. I put forward speculations and, as it were, certain imperfect attempts at the interpretation of causes . . . I outline and establish rules . . . or imperfect axioms which crop up in the course of inquiry. (OFB 12 15, modified)

The prominent role assigned to experiments was Bacon's decisive innovation, and this is another feature that sets Baconian natural history, including that of his many heirs, apart from classificatory natural history.[38] And it is this Baconian methodology that underlies Hooke's *General Scheme* and Boyle's 'Designe', both of which remained unpublished in the seventeenth century, and manifests itself in their natural historical writings. Let us scrutinise just one of Boyle's works, his *Short Memoirs for the Natural Experimental History of Mineral Waters* (1685) by way of illustration.

This work appeared just six years before Boyle's death and so is a late instalment in his broad natural historical agenda. First, note the title of the work: it is a work not just of natural history, but of 'Natural Experimental History'.[39] Second, note that it is a set of short memoirs, that is, it does not pretend to be a complete

[38] For more on Bacon's natural philosophical innovations, see Rees 2004.

[39] Boyle also used the term 'experimental history' in the titles of two of his works: *Experiments and Considerations Touching Colours . . . The Beginning of an Experimental*

history. Boyle would never presume to have delivered as much. In the Conclusion, he describes the work as an '*Idea* or Platform of a History of Mineral Waters, being a draught of, or a First essay upon, so difficult and uncultivated a Subject' (B 10 249–50). As for the content of the work itself, even though it appeared nearly two decades after he wrote the 'Designe' it is written in conformity with it (though it should be pointed out that Boyle rushed to publish the work before it was completed).[40]

For example, Part 1 of the 'Designe' requires a set of titles pertaining to the subject in question, and Boyle provides three sets of titles (sixty-eight in all) on mineral waters as examined at their source, as examined in the laboratory, and their medicinal effects (B 10 220–4, 247–9).[41] Part 2 of the 'Designe', that is, the body of the history, prescribes that each title be addressed, and *Mineral Waters* contains detailed comments on each of the second set of titles, as well as an extended section containing 'experimental remarks' on the thirteenth title pertaining to the use of galls (precursors to litmus tests) (B 10 234–47, 224–33). Again, Part 3 of the 'Designe' prescribes an appendix containing paralipomena (supplementary remarks) and loose experiments, and Boyle makes provision for these, though they also remain incomplete (B 10 224). As for the experimental content, we refer the reader to Noel Coley's excellent discussion and merely quote his assessment of the work: 'Significant improvements in mineral water analysis were suggested by Robert Boyle in 1684 [*sic*] . . . The chemical and physical techniques in his *Short memoirs* far surpass anything done previously, and represent an advance in inorganic analysis, both qualitative and quantitative' (Coley 1979, p. 207). Natural history, then, was intimately coupled with experiment insofar as the main method by which experimental philosophy was practised was the Baconian method of natural history.

3.3 Experimental Natural History and the Philosophy of Experiment

Baconian natural history was experimental. It was only natural, therefore, that when the experimental philosophers came to philosophise about the nature of experiment, they should do this in the context of experimental natural history. It so happens that the first well-developed philosophy of experiment in the history of philosophy, at least as far as we can determine, a philosophy that was developed over a number of decades, was set within the broader programme of

History of Colours (1664) and *New Experiments and Observations Touching Cold, or an Experimental History of Cold, Begun* (1665).

[40] See Michael Hunter's introduction to *Mineral Waters*, B 10 xxix–xxx.

[41] For a parallel Baconian natural history of mineral waters in Ireland, see William Petty's queries on mineral waters from 1684 and William King's 'Answers to the foregoing queries concerning Clonus water', in Hoppen 2008, 1, pp. 420–1 and 212–14.

Baconian natural history. This is the philosophy of experiment of Bacon, Boyle, and Hooke.[42]

It should be stated at the outset of our discussion of this philosophy of experiment that it was not widely embraced at the time, and neither was it developed beyond the generation of Boyle and Hooke. Moreover, it is important not to regard this philosophy of experiment as a necessary constituent of experimental philosophy;[43] the historical record shows that only a small handful of the advocates and practitioners of experimental philosophy were concerned with any form of philosophy of experiment. To be sure, one can find implicit, though simplistic, philosophies of experiment from the various defences of and recommendations for the practice of experiment during the period; one thinks of Oldenburg's defence of experiment that he forwarded to Sprat (see Section 2.4) and Petty's thirteen 'advertisements' for carrying out experiments at the Dublin Philosophical Society. Petty's sixth recommendation implies a commitment to experimental corroboration: he recommends correspondents 'make such observations as do depend upon the comparison of many experiments' (Hoppen 2008, 2, p. 897).[44] However, none of these provide a robust philosophy of experiment like that found in the writings of Bacon, Boyle, and Hooke.

The most helpful way into the philosophy of experiment that was tied to the Baconian theory of natural history is through its highly developed typology of experiments. From the various descriptors that they deployed, we can set up the issues that pertain to the epistemology of experiment that constitutes the Bacon, Boyle, and Hooke view.[45] Let us start with the more familiar types of experiments. We have already encountered Bacon's use of 'luciferous experiment' above (Section 3.3). Bacon frequently sets such experiments against fructiferous ones. In the *Novum organum* (1620), he introduces luciferous experiments as ones that enable us to discover 'real causes and axioms' (I, 70; OFB 11 113). He then mentions them in the context of a discussion of natural history. He tells us in Book I, aphorism 98 that 'we should have good hopes of natural philosophy once natural history (which is its basis and foundation) has been better organised'. Then, in the next aphorism he claims,

> hope of further advancement of the sciences will be well grounded only when we take and gather into natural history many experiments of no use in themselves but which only contribute to the discovery of causes, which experiments I have grown used to calling *Luciferous* as against *Fructiferous* ones. Now these former have a marvellous virtue and quality to them, namely that they never fail or let you down. For since we bring

[42] For a more detailed discussion, see Anstey 2014a.
[43] Levitin misinterprets us in this regard. See Levitin 2019, pp. 231–2, 242.
[44] For Petty's 'advertisements', see Hoppen 2008, 2, pp. 896–7.
[45] For a simpler, threefold division of experiments, see Rohault 1671, sig. éi^{r}–éij^{r}.

> them in not to accomplish any work but to show the natural cause in something, they suit their purpose whichever way they turn out because they settle the question. (OFB 11 157–9, with adaptations)

Here again is the association of luciferous experiments with the discovery of underlying causes of phenomena. This is in contrast with fructiferous experiments, which yield practical or economic outcomes, but which are of little or no use for natural philosophy. Boyle uses the distinction widely and with the same understanding of it as that of Bacon; however, he does warn against holding each category of experiment as mutually exclusive of the other:

> For though that famous Distinction, introduc'd by the Lord *Verulam*, whereby Experiments are sorted into *Luciferous* and *Fructiferous*, may be (if rightly understood) of commendable Use; yet it would much mislead those that should so understand it, as if Fructiferous Experiments did so meerly advantage our interests, as not to promote our Knowledg; or the Experiments called Luciferous, did so barely enrich our Understandings, as to be no other waies useful. For though some Experiments may be fitly enough call'd Luciferous, and others Fructiferous, because the more obvious and immediate Effect of the One is to discover to us Physiological Truths, and of the other to enable us to perform something of Use to the Possessour; yet certainly there are few Fructiferous Experiments, which may not readily become Luciferous to the attentive Considerer of them. For by being able to produce unusual Effects, they either hint to us the Causes of them, or at least acquaint us with some of the Properties or Qualities of the things concurring to the production of such Effects. And on the other side those Experiments, whose more obvious use is to detect to us the Nature or Causes of things, may be, though lesse directly, and in somewhat a remoter way, exceedingly Fructiferous. (B 6 433–4)

And it should be pointed out that Bacon and Boyle had markedly different natural philosophies such that they would have expected vastly different underlying causes to be revealed by the application of luciferous experiments.

Now both luciferous and fructiferous experiments have a heuristic structure: the former is aimed at causal explanation; the latter is aimed at practical outcomes. The former were more highly prized in the Bacon, Boyle, and Hooke view, but the latter were not to be dismissed. Bacon and his heirs were aware that the knowledge generated from some interactions with nature has a purely practical application.[46] And Bacon's distinction was widely deployed by his heirs in the latter half of the seventeenth century.[47]

[46] For Leibniz's discussion of a similar distinction, see his 'On the elements of natural science' (*c.* 1682–3), Leibniz 1969, pp. 282–3.

[47] For Hooke, see *General Scheme*, Hooke 1705b, pp. 21, 52 and *Philosophical Experiments and Observations*, Hooke 1726, p. 91. For the distinction in Hartlib, see his *Cornu copia* (Hartlib 1652); for Austen, see 'To the Reader' in Austen 1658, sig. A3^{v}; and for Sprat, see

A second distinction within the Bacon, Boyle, and Hooke view of experiment is that between experiments solitary and experiments in consort. This distinction cannot be understood in isolation from the method of natural history. It was first developed by Francis Bacon and is one of the organising principles for the multifarious observational and experimental reports in his posthumous *Sylva Sylvarum* (1626). It is hardly surprising then that it was used by Ralph Austen as early as 1658 in his *Observations upon Some Part of Sr Francis Bacon's Naturall History*.[48] The earliest appearance of experiments in consort in Boyle's published writings appears in *Colours* (1664), where he presents fifteen 'Experiments in Consort, Touching Whiteness & Blackness' (B 4 77–99), which constitute an ordered experimental series.[49] Boyle also deploys the distinction in his *Experimenta et Observationes Physicae* published in 1691, the year of his death. It is worth quoting from the latter work *in extenso*.

> i. Agreeably to this Advertisement you will find, that some of the Particulars that the following Treatise consists of, are single and as it were, Independent ones; upon which account they resemble those which in the *Verulamian Sylva*, or Natural History, are call'd *Experiments Solitary*: And have for that reason induc'd me to give that Title to each of the several Chapters that are made up of them.
>
> ii. Another sort of Chapters there is, wherein divers Experiments and Observations, all of them relating to the same Subject or Purpose, are set down together. These if they were rang'd and sorted in order to distinct Theories, I should call, in imitation of the mention'd Author, *Experiments in Consort*. But my backwardness to frame Theories has made me chuse to forbear as yet to methodize them, and therefore has made me think fit to call them only *various Experiments* and *Observations* about this or that Subject (which they belong to).
>
> (B 11 373)[50]

Note the way that he acknowledges the lineage from Bacon. Note too the way experiments in consort are those which pertain to a particular head of a natural history, whereas solitary experiments are free-standing. That this distinction

History of the Royal-Society, Sprat 1667, p. 245. For Jean-Baptiste du Hamel's references to luciferous experiments, see, for example, du Hamel 1701, pp. 183, 489, 575. For a passing reference to a luciferous experiment, see Graunt's 'Epistle Dedicatory' to Sir Robert Moray, Graunt 1662, sig. A4^{r}.

[48] Austen 1658, p. 1.

[49] For the connection between the solitary/consort distinction and natural history in an early manuscript addressed to Pyrophilus, see Royal Society Boyle Papers, vol. 10, fol. 138, transcribed in M. Hunter 2007a, p. 184, and Boyle 2008, pp. 12–13.

[50] For a sample of Boyle's laboratory notes on experiments solitary from 1686 to 1690, see Workdiary 37 (Royal Society Boyle Papers, vol. 21): www.livesandletters.ac.uk/wd/view/text_dip/WD37_dip.html (accessed 25 July 2022).

was widely appreciated and occasionally used is evident, for example, in Nehemiah Grew's publication of 1678, which was dedicated to the Fellows of the Royal Society and entitled *Experiments in consort of the luctation arising from the affusion of several menstruums upon all sorts of bodies exhibited to the Royal Society*. Interestingly, Grew's work is 'a Natural History of the Materia Medica' (Grew 1678, sig. A4^{v}), part of which he regards as being of great use to anyone constructing the natural history of a country.[51]

Another influential type of Baconian experiment is what Boyle coined the *experimentum crucis* in his *Defence against Linus* of 1662.

> And such an *Experimentum Crucis* (to speak with our *Illustrious Verulam*) is afforded us by that noble Observation of *Monsieur Paschall*, mentioned by the famous *Pecquet*, and out of him by our Author: namely, that the *Torricellian* Experiment being made at the foot and in divers places of a very high Mountain . . . he found, that after he had ascended a hundred and fifty Fathom, the Quicksilver was fallen two Inches and a quarter below its station at the Mountains foot; and that at the very top of the Hill it had descended above three Inches below the same wonted station. Whence it appears that the Quicksilver being carried up towards the top of the *Atmosphere*, falls down the lower, the higher the place is wherin the observation is made. (B 3 50–51)

Boyle here is alluding to Bacon's crucial instances as elaborated in the long thirty-sixth aphorism of the second book of the *Novum organum*.[52] In fact, this is Boyle's only use of the term, for he seems to have preferred to speak of experiments of 'great moment' and trials of 'such moment' (B 3 70).[53] But the term, as is well known, was used by Hooke in his *Micrographia* and elsewhere, and most famously by Newton in his letter published in the *Philosophical Transactions* describing his two prisms experiment.[54] For Bacon, crucial instances enable the natural philosopher to choose between two competing explanations of some phenomenon. This is precisely the sense in which Boyle uses the term in his *Defence against Linus*. There, he claims that Pascal's experiment confirms his own notion of the expanding spring of the air which pushes the mercury column down, against the contrary notion of Linus that an invisible *funiculus* contracts and in so doing holds the column of mercury up.

There are other categories of experiment such as promiscuous, loose, succedaneous, metrical, exploratory, probatory, and unsuccessful

[51] Grew 1678, p. 63. For du Hamel and Bacon's experiments solitary, see his 1672, p. 387.
[52] Bacon, *Novum organum*, OFB 11 319–39.
[53] See also John Locke, Draft A, §42, Locke 1990, p. 70, who speaks of 'proofs of greatest moment' and du Hamel 1672, p. 365.
[54] Hooke 1665, p. 54. See also Hooke 1674, 2; 1678, p. 55; Royal Society Classified Papers, xx.80 (Michael Hunter alerted us to this reference); Newton 1672a, p. 3078.

experiments,[55] but the typology is rich enough for us to see that most of the types are distinguished by their context of use and their outcomes. Thus, not only were experiments necessary constituents of experimental natural histories, but these experiments came to be categorised under different types reflecting, at least in the case of Boyle and Hooke, a fairly well-developed philosophy of experiment.

3.4 Baconian Natural History and the Early Royal Society

We contend that the main method by which experimental natural philosophy was practised in England in the last four decades of the seventeenth century was according to the Baconian method of natural history. This was the method, deriving from Bacon, that Boyle and Hooke theorised, practised, and, together with Henry Oldenburg, promoted in their publications from the mid-1660s to the early 1690s and which we discussed in Sections 3.1 and 3.2. The evidence for this claim is profuse and, to our mind, compelling.

From its earliest days, the Oxford Philosophical Club appears to have regarded their work in broadly Baconian terms, according a central place to the construction of a natural history of nature.[56] As early as 1651, Petty, who was part of the Oxford Club, was working on a history of concoctions.[57] And in 1652, Seth Ward speaks of how the members of the club 'have . . . gone over all or most of the heads of naturall philosophy & mixt mathematics collecting onely an history of the phenomena' from books and experiments (H. W. Robinson 1949, p. 69).[58] Interestingly, Ralph Austen's *Observations*

[55] For promiscuous experiments, see *Cold*, B 4 418–22; for loose experiments, see Boyle 2008, p. 6 and *Cold*, B 4 419; for succedaneous experiments, see *Human Blood*, B 10 96; for metrical experiments, see Royal Society Boyle Papers, vol. 9, fols. 120–2; for exploratory and probatory experiments, see Sargent 1995, pp. 170–6; and for unsuccessful experiments, see B 2 37–82. Leibniz refers to the latter in his *New Essays on Human Understanding*, Leibniz 1996, p. 305. For Hooke on unsuccessful experiments, see 'Things Requisite to a Natural History', Oldroyd 1987, p. 158 and Hooke 1726, p. 27.

[56] John Aubrey speaks of the 'Experimental Philosophy (secundum mentem Domini Baconi) at Oxford', Aubrey 2000 [1681], p. 342. Charles Webster claims of the Oxford club, 'members subscribed to a broad Baconian programme, which embraced [*inter alia*] the comprehensive survey of natural phenomena', C. Webster 2002, p. 161.

[57] See Hartlib Papers, 28/2/5B. The marginal entry just above the entry on Petty's history of concoctions is 'Oxford Pensa *Philosophicae Experimentalis*'. In fact, Petty was associated with a history of trades as early as 1647; see Hartlib to Boyle, 16 November 1647, *Boyle Corr.*, 1, pp. 63–4.

[58] In 1654, John Webster recommended:

> It cannot be expected that *Physical* Science will arrive at any wished perfection, unlesse the way and means, so judiciously laid down by our learned Countreyman the Lord *Bacon*, be observed, and introduced into exact practice; And therefore I shall humbly desire, and earnestly presse, that his way and method may be imbraced, and set up for a rule and pattern:

upon Some of Sr Francis Bacon's Naturall History of 1658 – which was dedicated to Boyle – may well be the inspiration behind Boyle's claim from this period that his experiments related in *Certain Physiological Essays* 'were in my first Design collected in order to a Continuation of the Lord *Verulam's Sylva Sylvarum*, or Natural History' ('Proëmial Essay', B 2 17).[59] Another natural historical work written in Oxford and dedicated to Boyle around this time and with which he was involved, was Robert Sharrock's *The History of the Propagation and Improvement of Vegetables* (1660). Moreover, there is also evidence of an early interest in Baconian natural history amongst future Fellows of the Royal Society who were not connected with Oxford. For example, in early 1657 Hartlib wrote of William Croone, 'Mr Croone a great wisher and vndertaker for composing of a Natural History. Natural History. As likewise of a History of Trades'.[60]

We now know that by the early 1660s neither Boyle nor Hooke had worked out their own theory of natural history in detail.[61] Nevertheless, even before the Baconian method was fully theorised by Boyle and Hooke, it had informed the practices of the Royal Society and had begun to evidence itself in an array of publications. Thus, for example, a Royal Society Committee for Collecting Natural Phenomena was formed in 1664 that was conceived in explicitly Baconian terms, as we can see from the following extract from John Hoskins' report on its method:

> Resolving it best to divide the worke among the severall members of the Society . . . each person that shall take a share the directions given for that end by my Lord Bacon in a treatise written by him called *Parasceve ad historiam naturalem* and that accordingly they will divide the observations of the phaenomena of nature into observations of generations, pretergenerations and arts but the last is to bee left to the care of the Committee for Trades . . . This Committee [for collecting phenomena] likewise make it their request to the society that other Committees bee desired upon occasion to consider the same method and rules of my Lord Bacon that so they may all agree. (Hunter 1989d, pp. 104–5)

> that no *Axioms* may be received but what are evidently proved and made good by diligent observation, and luciferous experiments; that such may be recorded in a general history of natural things, that so every age and generation, proceeding in the same way, and upon the same principles, may dayly go on with the work, to the building up of a well-grounded and lasting Fabrick, which indeed is the only true way for the instauration and advance of learning and knowledge. (J. Webster 1654, p. 105)

[59] See also Hartlib Papers, 29/6/10A.

[60] Hartlib Papers, 29/6/11A.

[61] See Anstey and Hunter 2008 for the development of Boyle's theory of natural history and discussion of how it manifests itself in his published writings.

The commitment to Baconian natural history is striking, not least in that it cites Bacon's *Parasceve* and the tripartite division of natural history into generations, pretergenerations, and arts. Indeed, what we find is that the structure of the Society's various committees at this time in large part derived from its conception of Baconian natural history.[62] And this is precisely the time when Boyle began to conform his practice of experimental natural history to the Baconian method of natural history. From this point on, Boyle developed his 'Design', and his subsequent natural philosophical output was carried out under its rubric; this appears to be a genuine case of the Society's impact on Boyle's own natural philosophical method. This occurs around 1664, and the first work to be published according to his 'Designe' is *Cold* of 1665.[63] As pointed out in Section 3.2, a parallel development can be found in the writings of Robert Hooke.

Yet in order to establish our claim that Baconian natural history was widely practised in England in the final decades of the seventeenth century, it is incumbent on us to specify which Fellows, other than Boyle and Hooke, were actively involved in the Society's Baconian-style committees and practised a form of Baconian natural history. Here we can only provide a small sample of the evidence.[64] The place to start is with some of the Society's committees in the early 1660s. The committee on trades, an important facet of the Baconian programme, was chaired by Christopher Merrett. The committee for the history of agriculture included Merrett, Wilkins, Croone, and Henshaw. Merrett seems to have been particularly active, producing such things as 'a List of what is cultivated in England' for the agricultural committee (Hunter 1989d, p. 109).[65]

Importantly, most of these Fellows had been involved in a variety of natural historical projects at the Royal Society since its early days. We can hardly survey the full range of evidence for this here. Instead, we will take just one example, that of Christopher Merrett, and set out some of his activities at the

[62] See Hunter 1989d, p. 92. For the continuing importance of natural history in the remit of the Royal Society, see 'A proposal for the Advancement of the Royall Society' by A. B. in Hunter and Wood 1989, pp. 225–31, esp. 226 and 228.

[63] The full title is *New Experiments and Observations Touching Cold, or an Experimental History of Cold, Begun*. For a detailed treatment of this development in Boyle's method, see M. Hunter 2007b.

[64] Practitioners of Baconian natural history among fellows of the Royal Society and those within its ambit include, *inter alia*, John Aubrey, Ralph Austen, John Beaumont, Ralph Bohun, Robert Boyle, Walter Charleton, Joshua Childrey, William Clarke, William Croone, John Evelyn, John Graunt, Nehemiah Grew, Edmund Halley, Thomas Henshaw, Robert Hooke, Christopher Merrett, William Petty, Robert Plot, Robert Sharrock, and John Woodward.

[65] For the published list of queries associated with this committee, see *Philosophical Transactions*, 1.5, pp. 91–4. See also *Boyle Corr.*, 2, pp. 313–14. See also Lennard 1932.

Royal Society from March 1661 to December 1662 as recorded in the first volume of Birch's *History of the Royal Society*.[66]

According to Birch's *History*, on 2 January 1661 Merrett was requested 'to bring in the history of refining', and a week later he was 'continued for the history of refining', which he delivered at the meeting on 16 January, following this up with an appendix the next week which was subsequently published in the *Philosophical Transactions* (Birch 1756–7, 1, pp. 8, 10, 12, 16);[67] on 25 March, he was asked for a catalogue of trades deriving from Evelyn and Petty and on 3 April,[68] together with Boyle and Mr Colwall, was asked to 'draw up an account of the manner of making vitriol' (pp. 19, 20); on 15 May, he joined the library committee which was also charged with 'examining the generation of insects' (p. 23); on 16 October, he was asked, together with Timothy Clarke, to bring their account of trades to the next meeting (p. 50); on 17 September 1662, he was asked to consider Moray's paper on timber, and he read a paper on this subject at the 1 October meeting (pp. 111, 114); on 22 October, he mentioned that live worms are sometimes found in the guts of salmon, and this led to a discussion of spontaneous generation, and at the same meeting he and Charleton were asked to develop a classification system for fish (pp. 117, 118); they were also asked to bring their observations on the preservation of delicate wines (p. 126); then on 3 December Merrett gave an account of some of his experiments on freezing and he was asked to write this up and to take into consideration Oldenburg's 'inquiries concerning freezing' (p. 141). Finally, on 17 December 1662, 'Dr Charlton promised to communicate to the next meeting his observations upon the ordering of wines', and at the same meeting, Dr Merrett's own observations were read.[69]

Charleton's observations subsequently found their way into print as the second of his *Two Discourses* (1669). The observations were entitled 'The Mysterie of Vinters'; they were organised under 'Generals or Heads', referred to Boyle's *History of Cold*[70] and were described by Charleton as 'this *Essay* toward a History of Wines'.[71] This natural history is followed by that of Merrett entitled, 'Some Observations concerning the Ordering of Wines', which reproduces the observations read to the Royal Society in December 1662.

More importantly, however, Merrett contributed a long appendix to Boyle's *History of Cold* (1665), which relates the extensive series of experiments on freezing that Merrett had communicated to the Royal Society in December 1662).[72] We have seen that Boyle's *Cold* was the first of his natural

[66] For Merrett's experimental work, see Koinm 2000.
[67] See Merrett 1679.
[68] For Petty's 'History of Trades', see Petty 1967, pp. 205–7.
[69] Birch 1756–7, 1, pp. 156–62.
[70] Charleton 1669, p. 167.
[71] Charleton 1669, p. 200.
[72] See B 4 525–42. In a letter to Samuel Sorbière, Oldenburg describes Boyle's *Colours* and Boyle and Merrett's *Cold* as 'Histoires Experimentelles', *Oldenburg Corr.*, 2, p. 141.

historical writings that was carefully constructed in conformity with his 'Designe about Natural History',[73] and Merrett's appendix forms a natural complement to this exemplar of Baconian natural history.[74] Furthermore, the history refers to a set of 'ingenious *Quaeries*' on the subject by Thomas Henshaw and, as we might expect, cites Bacon's *Sylva Sylvarum*.[75] As for Thomas Henshaw, Thomas Sprat published his 'History of the making of Salt-peter' as the first of three exemplars of the Society's approach to natural history.[76] Sprat's second exemplar history on dyeing is by William Petty, another active member of the early Royal Society, and it is worth noting that Sprat also published Hooke's 'A method for making a history of the weather' accompanied by a 'Scheme' that resembles that recommended by Boyle and kept for many years by Locke.[77]

Of course, some active Fellows did not participate in natural historical projects at all, though many were well aware of their importance. John Wallis, for example, did not write any natural histories, and yet in a letter to Boyle, he laments the lack of a history of the tides by which he can test his own hypothesis on the ebb and flow of the sea and was waiting for the time when he would have the leisure 'to prosecute this designe' (*Boyle Corr.*, 3, 143).

In addition to the diversity of Fellows involved in the practice of Baconian natural history, we also find it encompassed a diversity of genres. Lists of queries, answers to queries, observations from the past, experimental reports,

Among Merrett's contributions to the history of trades is his translation, with his own extensive observations, of Neri's *The Art of Glass*, which he dedicated to Boyle. See Neri 1662 and Ochs 1985, and for the significance of Merrett's contribution, see W. E. S. Turner 1963. For Merrett's explicit statement of the Baconian nature of the work, see Neri 1662, pp. 205–6. For further discussion of Merrett and natural history, see Cook 1989, pp. 256–8.

[73] See Anstey and Hunter 2008, pp. 101, 103, and 109.

[74] It is worth pointing out that on 27 February 1683/4, William Croone delivered an account of four experiments to the Royal Society on the dilatation of water by cold that were related to Boyle's *Cold* and to which book Croone alludes. See Birch 1756–7, 4, pp. 263–4 and Boyle's *Cold*, B 4 319–24.

[75] B 4 525 and 542.

[76] Sprat 1667, pp. 260–83. Henshaw's history was harshly criticised by Stubbe, who warned 'the *History of Nature* which they propose to themselves, will not merit any more Credit . . . then that of *Pliny*; and these *Experimentall Philosophers* instead of *undeceiving* the age as to *inveterate Errors* will *multiply new ones*' (Stubbe 1670b, p. 35). For further analysis, see Robertson 2020. Henshaw also licensed Grew's *Experiments in Consort of Luctation*, 1678.

[77] For Petty's history of dyeing, see Sprat 1667, pp. 284–306 and for Hooke's method for a history of the weather, Sprat 1667, pp. 173–9. Locke's early weather charts were published in Boyle's posthumous *A General History of the Air*; see B 12 70–88. For Robert Plot's weather records for Oxford in 1684, see Plot 1685. For Martin Lister's method of taking barometric readings and general background to the recording of weather in this period, see Roos 2011, chapter 11. For John Warner's method of recording the weather in his *Aeroscopium*, see Gunter 1923–45, 12, pp. 302–5.

travellers' reports, chorography, works of 'biological' classification, all came under the rubric of experimental natural history. Thus, for example, John Graunt describes his work on bills of mortality as a natural history, linking it explicitly with Bacon's own histories of life and death.[78] Likewise, William Petty's 'Materialls for a New History of Life and Death' was composed as an extension of Bacon's history, to which Petty alludes in his title.[79] John Beale writing to Boyle in 1681 claims that Plot's *History of Oxford-Shire* is 'the best ... that I have yet seen' in following Boyle's instructions for writing a natural history in his 1666 'General Heads for a Natural history of a -Countrey'.[80] To these we can add Hooke's lectures on the history of trades of salt-making and felt-making.[81] To be sure, the carefully structured histories of Boyle, such as *Cold* and *Mineral Waters*, were the high-water mark when measured against his methodological strictures, but a toleration for genre diversity was the hallmark of the enterprise, as we see even in works such as the loose compilation that is Boyle's *General History of the Air*.

3.5 The Decline of Experimental Natural History

It is beyond dispute that from the mid-1660s to the 1680s there was a proliferation of experimental natural histories in England, and Bacon's own natural historical works were widely read and discussed. The most important of these, the *Sylva Sylvarum*, was republished twice in the 1680s.[82]

[78] Graunt writes:

> The Observations, which I happened to make ... upon the *Bills of Mortality,* have fallen out to be both *Political,* and *Natural,* some concerning *Trade,* and *Government,* others concerning the *Air, Countries, Seasons, Fruitfulness, Health, Diseases, Longevity,* and the proportions between the *Sex,* and *Ages of* Mankinde. All which (because *S^r. Francis Bacon* reckons his Discourses of *Life* and *Death* to be *Natural History;* and because I understand your selves are also appointing means, how to measure the Degrees of Heat, Wetness, and Windiness in the several Parts of His Majestie's Dominions) I am humbly bold to think *Natural History* also, and consequently, that I am obliged to cast in this small *Mite* into your great *Treasury* of that kinde. (sig. A3^v)

[79] See Petty 1967, p. 187–9. For further discussion of Graunt and Petty, see Rusnock 2002, pp. 17–18.

[80] Beale to Boyle, 2 March 1681, *Boyle Corr.*, 5, pp. 244–5. For Beale's own writings as Baconian natural histories, see the enclosure with Beale to Boyle, 9 November 1663, *Boyle Corr.*, 2, pp. 173–4.

[81] See, for example, Hooke, 'History of Salterns', 'Making salt in a Hampshire Saltern', Royal Society Classified Papers, 20/42, 40; 'For the better making a history of the Weather' and 'The making of a more accurate history of the Weather', Royal Society Classified Papers, 20/2, 24. For the lecture on felt-making, see Andrade 1950, p. 184 and plate.

[82] Bacon's *Sylva Sylvarum* was Bacon's most popular work in the period, going through numerous editions. It was published in 1683 and 1685 but never published as a separate work in the eighteenth century.

By the final decade of the seventeenth century, however, the evidence suggests that the practice of Baconian natural history began to decline, and the methodological substructure of Baconian natural history had begun to fade from view. This becomes clear when we analyse the different strata of writings that fall under the broader project of natural history that appeared during the decade.

A good barometer in this regard is William Wotton's *Reflections on Ancient and Modern Learning* (1694) because of its attempt to justify the new philosophy in the battle of the books. Wotton provides a nice summary of the central tenets of experimental philosophy, and he mentions the collecting of 'a perfect History of Nature'.[83] Surprisingly, however, the list of natural historians that he provides – a list that includes Isaac Barrow, Newton, Huygens, Malpighi, Antonie van Leeuwenhoek – implies that he is working with an anaemic, generalised conception of natural history. Furthermore, the manner in which he treats natural history in earlier chapters reveals that he considers it in traditional terms as collecting and describing, and he provides no elaboration of the method in neo-Baconian terms.

The same can be said of the lesser-known work by Thomas Robinson, entitled *New Observations on the Natural History of this World of Matter and this World of Life* (1696). This shows no influence of and makes no reference to Baconian natural history at all. Nevertheless, Robinson is acutely aware of the distinction between experimental and speculative philosophy and the reticence of experimental philosophers to reason from principles. In his 'Dedication', he contrasts the 'Theorical Part of Philosophy' with the 'practick or experimental part', and before listing the 'postulata' from which he reasons, he comments that 'I know that it's much out of Fashion to beg Principles in this Philosophizing Age' (T. Robinson 1696, sig. a2^{r}).

As for methodological writings, the publication of various works concerning queries and articles of inquiry for natural histories in the 1690s suggests that there was a continued interest in the Baconian program. For example, as noted in Section 3.1, Boyle's 'General heads for the history of a Countrey great or small' of 1666 was reissued in a modified and expanded form in 1692 and then again in 1700.[84] Furthermore, in 1696 John Woodward published his own derivative version of Boyle's 'General heads' as *Brief Instructions for making observations in all parts of the World*. Woodward's twenty-page booklet complemented his own *Natural History of the Earth*, which itself followed the Baconian method and which is discussed below. It might, therefore, be thought

[83] Wotton 1694, pp. 300–7.

[84] Michael Hunter points out concerning Boyle's 'General heads', 'Thereafter, versions of Boyle's 'General Heads' continued to appear in an almost emblematic position in collections of travel writings into the eighteenth century, for instance in Jean-François Bernard's *Recueil des voyages au nord* of 1715–27', M. Hunter 2007b, p. 20.

that the republication of Boyle's influential work is an indicator of the level of interest in the Baconian program, but, in fact, it is more likely represents an opportunistic publishing venture trading on the recently deceased's great name and the flurry of posthumous publications that followed his death. The fact that most of the additional material that was included in the reprint derives from *Philosophical Transactions* articles of the 1660s reinforces the sense that this work is more a nostalgic rehash than a cutting-edge publication of the new philosophy.[85] This is not to say that the 'General Heads' and *Brief Instructions* were not used by natural historians. They were sought by writers of county histories.

Indeed the writing of county histories was going from strength to strength in the 1690s, inspired by the grand design of Robert Plot, whose *Natural History of Oxford-Shire* (1677) had become a kind of template for other such county histories of Britain. (It was even proposed that Plot be given a lectureship at Oxford in 'philosophical natural history'.[86]) As we noted in Section 3.1, Plot's first history was conceived as applying the Baconian method. Plot himself in the 1680s became a nodal point for natural historians such as John Beaumont. Beaumont published his *A Draught of a Design for the Writing of the History of Nature and Arts of the County of Somerset* in 1685,[87] and Plot's protégé, Edward Lhuyd, produced sets of queries for a county history of Wales in the 1690s.[88] But a perusal of the correspondence of the Oxford Philosophical Society, and in particular that of Plot, shows that, on the whole, the natural history pursued by those within its ambit was increasingly conceived either as descriptive and classificatory or as regional ethnographic and even lexicographical encyclopedias. Thus, the first volume of Lhuyd's ambitious projected history of Wales was a *Glossography* of grammars and comparative etymology, and his work on fossils, *Lithophilacii Britannica ichnographia* (1699) was purely taxonomic, without a hint of the Baconian method. Most of the other county natural histories or proposals for such histories produced in this period, such as R. B's *History of Wales* (1695), Charles Leigh's *Natural History of Lancashire, Cheshire and the Peak in Derbyshire* (1700), or John Browne's *Proposals by Way of Contribution for Writing a Natural History of Yorkshire* (1697), do not contain any reference to the Baconian method at all.

Martin Martin's *A Description of the Western Islands of Scotland* (1703) provides yet another example. Martin is aware of the important place of natural history in experimental philosophy: 'Natural and Experimental Philosophy has been much improv'd since his [Donald Munro] days, and

[85] For the source of the additions, see B 5 xli–xlv.

[86] See A. J. Turner 2004. Plot added a codicil to his will stating that should his two sons die without issue, he would bequeath to the University of Oxford money 'for a Perpetual Lector for Natural History'. See Gunter 1923–45, 12, p. 418.

[87] Published in Gunter 1923–45, 12, pp. 275–8.

[88] See Lhuyd 1695 and 1697.

therefore Descriptions of Countries without the Natural History of 'em, are now justly reckon'd to be defective' (1703, sig. a4[r]). However, Martin's book shows no awareness of the Baconian method.

Another telling indicator that the method of Baconian natural history was in decline is the dearth of new histories of substances, qualities, processes, or states of matter. In the decade after the appearance of Boyle's *General History of the Air* in 1692, no one appears to have continued this distinctive aspect of the Baconian agenda, though in physic the project for compiling natural histories of disease continued unabated.[89] What did emerge were a handful of natural histories of the Earth, and it is worth comparing these with a new form of cosmogonical writing that appeared for the first time in the mid-1690s.

It is highly instructive here to juxtapose John Woodward's *An Essay Toward a Natural History of the Earth*, which appeared in 1695, with William Whiston's *A New Theory of the Earth* published in the following year. The former opens with a Baconian preface and, as its title suggests, is written under the rubric of Baconian natural history. The latter, by contrast, is written mimicking the style of Newton's *Principia*, using phenomena, scholia, and corollaries. The contrast could not be more striking. Woodward's book harks back to the natural historical agenda of the past; Whiston's picks up the new direction in which experimental philosophy was now heading: a mathematical form of natural experimental philosophy that bore little resemblance to its natural historical forebear.

Further evidence that the Baconian vision was fading from view is found in such reference works as John Harris' *Lexicon Technicum*. The second edition of volume one (1708) defines 'Natural History' in classificatory terms as 'a Description of any of the Natural Products of the Earth, Water or Air, such as Beasts, Birds, Fishes, Metals, Minerals, Fossiles, together with such *Phaenomena* as at any time appear in the Material World; such as Meteors'. The inclusion of earth, air and water does reflect the enlarged scope of the Baconian conception, but the focus on natural kinds certainly suggests that Harris primarily has classificatory natural history in mind. It is little wonder then that Harris' own massive *The History of Kent* (1719) lacks any reference to Baconian natural history in its prefatory material, structure, or content. Chambers' *Cyclopaedia* of 1728 reveals the impact of Baconian natural history insofar as it includes meteorology, hydrology, mineralogy, phytology, and zoology within the remit of natural history.[90] Yet the article contains no reference to the theory of natural history that gave rise to the extension of the discipline beyond natural kinds.

It is only natural to conjecture as to the underlying causes of the decline of Baconian natural history in the 1690s. Yet here one must proceed with caution,

[89] See T. Molyneux 1694 and in Italy, Baglivi 1696.
[90] See Yeo 2003, pp. 256–7.

for it is extremely unlikely that any definitive story can be reconstructed from the many causal factors that were in play. What we offer here is a non-exhaustive list of factors that need to be taken into account in any explanation of the decline of Baconian natural history in the last decade of the century.[91]

First, there are circumstantial factors. The death of Boyle in 1691 deprived the methodology of its ablest exponent. Second, there is the failure of the methodology to come to completion and to produce the kind of natural philosophical theories that were hoped for. And third, there is the emergence of a highly successful new natural philosophical methodology. The second and third points are worthy of detailed elaboration.

Boyle's *Human Blood* was out of date when it appeared in 1684,[92] and his posthumous *General History of the Air* of 1692 did not advance the subject beyond what was known two decades earlier. The one novel area where the Baconian method was deployed with significant innovation and results was in geology or the history of the Earth. Here, however, there was a tendency for premature speculation, particularly when theological considerations entered the fray. By the 1690s, patience must have been running out for the Baconian method, and all the promissory notes of the writers of natural histories were beginning to sound like so much hollow rhetoric. There was simply a lack of results relative to the enormous labour that had been expended and all the labour yet required to bring the work to completion.

As early as 1676, Leibniz, in a preamble to a dialogue on motion that he penned after visiting London, had an interlocutor say, 'I am amazed at how many excellent observations we have . . . at how many elegant experiments the chemists have performed, at what an abundance of things the botanists or anatomists have provided, which philosophers have not made use of, nor deduced from them whatever can be deduced' (Leibniz 2001, p. 133). Robert Hooke was keenly aware of this by the mid-1680s, for he opened a new series of lectures on fossils, probably delivered in December 1686,[93] with a comment in defence of both the Royal Society's experiments and trials and the collecting of observations. Concerning the latter he says, 'tho' the things so collected may of themselves seem but like a rude heap of unpolish'd and unshap'd Materials, yet for the most part they are so qualified as that they may be fit for the beginning, at least of a solid, firm and lasting Structure of Philosophy' (*A Discourse of Earthquakes*, Hooke 1705c, p. 329; see also p. 330.)[94] Now, given that this is the preface to a lecture defending his explanation of the origin of fossils, the 'things

[91] See also Anstey 2015.

[92] See Knight and Hunter 2007.

[93] For the dating of Hooke's lectures on earthquakes, see appendix 1 in Rappaport 1986, pp. 143–6.

[94] According to William Rawley, Bacon feared that his materials in *Sylva Sylvarum* 'may seem an undigested heap of particulars' whereas, in fact, they were 'fundamental to the erecting and building of a true philosophy', SEH 2 335–6.

so collected' that are in view are not merely the specimens of classificatory natural histories. Indeed, Hooke's reply to the unnamed critics is a defence of all of the Society's activities which the critics claimed had achieved 'just nothing' (Hooke 1705c, p. 329).

Nevertheless, earlier that year there is some evidence of discontent with those within the Society who emphasised classificatory natural history. William Molyneux, who had just been elected a Fellow,[95] wrote to Edmund Halley from Dublin on 8 April 1686 thanking him for disabusing him about the Society because he (Molyneux) had heard from a someone that there was:

> a party arising in the Society, that were for rejecting all kinds of useful knowledge except ranking and filing of shells, insects, fishes, birds, &c. under their several species and classes; and this they termed *Natural History*, and *Investigating Nature*, never attending to the uses and properties of these things for the advantage of mankind, and reckoning chemistry, astronomy, mathematics, and mechanics, as rubs in their course after nature. (Birch 1756–7, 4, p. 476)

Molyneux goes on to imply that he is relieved that there is no such 'party' that so badly misunderstands the true nature and value of natural history. Mordechai Feingold views this as evidence of a situation polarised around the mathematicians and the natural historians, each vying for methodological ascendancy within the Royal Society.[96] However, this is going too far, for, *pace* Feingold, there is hardly any evidence of any anti-mathematical sentiment amongst the natural historians, and, more importantly, many of those adept at mathematics were partial to natural history. Molyneux himself is a nice example here, for he was a practitioner of natural history. Indeed, two years earlier Molyneux had a communication on the Connough Worm published in the *Philosophical Transactions*. This bears the hallmarks of a contribution to a Baconian natural history, for on receiving the worm he immediately proposed 'some queries' concerning it, especially to determine if any experiment had proven it to be venomous. Then, after reflecting on an experimental trial about which he felt some diffidence, he says, 'but leaving these conjectures, I come to what is evident to the senses (and experimental philosophy ought to go no further)' (W. Molyneux 1684, pp. 876, 879).[97]

Again, later that year Molyneux's correspondent Edmund Halley wrote to John Wallis of the Oxford Philosophical Society about his *Historicall Account of the Trade Winds and Monsoons*, describing the topic as 'a part of natural history not less desirable and useful than it is difficult to obtain' (Halley 1687, p. 153).[98]

[95] William Molyneux was elected FRS on 3 February 1686.
[96] Feingold 2001, pp. 84–7.
[97] For William Molyneux's Baconian queries relating to Lough Neagh, see Hoppen 2008, 1, p. 353.
[98] Note the reference to Varenius on the same page.

This work appeared in the *Philosophical Transactions* in the very month that Hooke resumed his lectures on earthquakes with his defence of natural history. Halley clearly saw himself as contributing to an experimental natural history.

It may well be that many of the criticisms of the practice of classificatory natural history in the Society in early 1686 arose from frustrations surrounding the publication of Francis Willughby's *Historia piscium*, which involved at least ten Fellows and drained the Society's coffers, thus leading to Halley having to carry the cost of the publication of Newton's *Principia*.[99] Whatever the case, the publication of the *Principia* was to have significant implications for the long-term prospects of Baconian natural history. The Newtonian method, when placed alongside the method promoted by the likes of Boyle and Hooke, seemed already to have generated new knowledge and had issued a whole new and exciting set of possibilities for further investigation. To many it even seemed possible to apply the Newtonian mathematical method to seemingly unrelated disciplines such as medicine and natural religion.[100] Others realised that they needed to adjust their natural philosophical methodology to accommodate the new Newtonian approach. The most important example here is John Locke, who came to revise his views on the role of principles as the significance of the Newtonian achievement dawned on him in the 1690s.[101]

Some aspects of the Baconian method of natural history were widely embraced and of immediate use and impact for natural philosophers and physicians in the last four decades of the seventeenth century. And one can document easily enough an acceptance of the Baconian programme in its broad outline and some of its salient techniques. These include the use of lists of queries and articles of inquiry, the use of testimony such as the widespread use of travel literature, a commitment to a two-stage process of theory construction in which natural history constitutes the first necessary stage, and a wide acceptance that the whole project is a massive undertaking, too large for any single philosopher and one that had to be supported by institutional and international collaboration. However, only two experimental philosophers gave full theoretical elaborations of this method, namely, Boyle and Hooke. And apart from their most vocal and well-connected propagandist, Henry Oldenburg, very few of the Fellows or any other practising natural philosophers show any attempt to follow the contours of the Baconian method in detail.

When Sir Thomas Blount published his *A Natural History Containing Many not Common Observations Extracted out of the best Modern Writers* in 1693, it is clear that he regarded a natural history to be a collection of matters of fact derived from observation. He is fully conscious that his volume is small compared to a subject 'of the largest Field', and he draws from many of the leading

[99] See Kusukawa 2000, pp. 185–7.
[100] See Guerrini 1985, 1996, 2000; Anstey 2017b.
[101] See Anstey 2011a, chapter 8.

natural philosophers of his generation. We can discern, therefore, the Baconian origins of this work. Yet Blount himself seems to be oblivious to these origins. The theoretical substructure that gave rise to the branding of such profuse and disconnected observations as a natural history had all but disappeared.

The same can be said with regard to the Bacon, Boyle, and Hooke philosophy of experiment that is grafted onto the Baconian theory of natural history. There is no doubt that various facets of this philosophy of experiment were influential, such as the notion of *experimentum crucis*, and yet no one apart from Boyle and Hooke fully appropriated it or developed a serious competitor. The Bacon, Boyle, and Hooke philosophy of experiment should certainly not be seen as a necessary constituent of early modern English experimental philosophy, even if it was an important, and hitherto underappreciated, facet of that movement.

3.5 Conclusion

This chapter has provided an overview of the primary way that experimental natural philosophy was practised in England in the final four decades of the seventeenth century. This was the Baconian method of natural history that was practised by a host of virtuosi in England and beyond. We have argued that this form of experimental natural history ought to be differentiated from classificatory natural history in terms of its remit, its methods – including the essential role for experiment – and its accompanying philosophy of experiment. Indeed, from the perspective of its leading theorists and promoters, this new form of experimental natural history effectively subsumed classificatory natural history. However, with respect to the actors themselves, we would not want to put too fine a point on this, for there is ample evidence that some did not see the difference between experimental and classificatory natural history in such clear-cut terms.

The leading English botanist John Ray, for example, looking back in 1690, was able to thank God that he was 'born in this last age when ... has arisen a philosophy solidly built upon a foundation of experiment'. He regarded it as 'an age of daily progress in all the sciences, especially in the history of plants', which he described in classificatory terms as 'the procuring, cultivating and depicting of plants', and he proceeded to address 'those who condemn the study of Experimental Philosophy' (Raven 1950, p. 251). Clearly, Ray was apprised of the emergence and significance of experimental philosophy, and yet he conceived of the history of plants, his own discipline, in classificatory terms.

We have also argued that experimental natural history began to go into decline in the decade that follows Ray's reflections. And while we suggested a clutch of underlying causes to account for this, it should not be thought that there was a concomitant decline in the experimental philosophy movement. Far from it, for the 1690s heralded the heyday of experimental philosophy, as we document in Part II.

PART II

The Heyday of Experimental Philosophy

CHAPTER 4

Mathematical Experimental Philosophy

By the third decade of the eighteenth century, mathematical natural philosophy had largely displaced natural history as the predominant approach to the practice of experimental natural philosophy in Britain. The process by which this happened is complex. Experimental philosophers continued to oppose speculation and hypotheses, but they now championed a mathematical rather than a natural historical method to address natural philosophical questions. The method of experimental natural history receded into the background, and a new mathematical method of experimental philosophy came to prevail. The central figure in this transition was Isaac Newton.

This chapter examines this important development in the history of experimental philosophy. It begins with a survey of the young Newton's early exposure to experimental philosophy and then turns to the emergence of experimental pedagogy in the last years of the seventeenth century and its rapid expansion in the early decades of the century that followed. The proliferation of courses in experimental philosophy, both public and university-based, is testimony to its success and legitimacy. So much so, we argue, that when his commitment to universal gravity came under attack by Continental detractors, Newton openly and very strategically aligned himself with experimental philosophy, in part because of the credibility that this approach to natural philosophy already possessed. We document the process by which Newton publicly declared himself to be an experimental philosopher in the second edition of the *Principia* of 1713 and then go on to examine his role in the eclipse of Baconian natural history.

4.1 Newton's Early Exposure to Experimental Philosophy

Newton is the single most important figure in the development of experimental philosophy after Boyle. He was exposed to experimental philosophy as a student in Cambridge in the early 1660s when he encountered the method of Baconian natural history in Boyle's *Colours* and *Cold* and the notion of experimental philosophy in Boyle's *Spring of the Air* of 1660, from which he

took notes in his Trinity Notebook.[1] In addition, Newton took notes on the first twenty-three issues of the *Philosophical Transactions*, probably around 1667 when he purchased them, and Sprat's *History of the Royal-Society*.[2] This too exposed him to the new approach to natural philosophy promoted by Boyle and Oldenburg. His early optical writings from 1672 to 1675 show that he was fully cognisant of the ESD: he is very cautious with regard to hypotheses and gives experiment a central place in his fledgling methodology.[3] It is true that he nowhere uses the term 'experimental philosophy' in any of these early writings, but at the same time he was associated with experimental philosophers, and his work was naturally understood by Oldenburg as a contribution to experimental philosophy. So, for example, Oldenburg recommends Newton's queries relating to his theory of light and colours in the *Philosophical Transactions* 'to the Industry of the Lovers of Experimental Philosophy' (Newton 1672c, p. 5004).[4] More importantly, Newton's writings from this period bear the clear imprint of experimental philosophy.

In fact, Dana Jalobeanu has persuasively argued that Newton's first and most important early optical paper, the 'New Theory about Light and Colors', contains a number of features that derive from Bacon's theory of natural history.[5] Jalobeanu's insight here can be extended such that Newton's early optical work is naturally contextualised within the early Royal Society's program for experimental philosophy. One of the inspirations for Newton's early work on colour was Boyle's *Colours* of 1664, which he subtitled 'the beginning of an experimental history of colours'. The book was available in May 1664, and Newton apparently made notes on it from mid-1664 to early 1665.[6] From 1666, the young Newton began a series of optical experiments and observations of which he gives a telescoped account in his seminal 'New Theory' paper of 1672. This paper alludes in a number of places to Boyle's earlier *Colours*. For example, in proposition 11 Newton refers to colour phenomena associated with *Lignum nephriticum*, leaf gold, and glass, each of which were discussed in Boyle's earlier work.[7] Newton also explicitly refers to Hooke's *Micrographia* in proposition 12.

[1] For Newton's notes on Boyle, see McGuire and Tamny 1983; on *Colours*, pp. 370, 440–62 *passim*; on *Cold*, pp. 362–6; on *Spring of the Air*, pp. 348, 370–2, 390, 400, 426.

[2] See 'Out of Philosophicall Transactions', Cambridge University Library MS Add. 3958, fols. 9^{r}–15^{r}. For the purchase of the *Transactions* and Sprat's *History*, see Fitzwilliam Notebook, fol. 6^{v}:www.newtonproject.ox.ac.uk/view/texts/normalized/ALCH00069 (accessed 30 September 2021).

[3] See Anstey 2004.

[4] See also Linus to Oldenburg, 6 October 1674, where Linus calls Kenelm Digby 'that worthy Promotour of Experimentall Philosophy', *Newton Corr.*, 1, p. 318. This letter was later published in the *Philosophical Transactions* and almost certainly came to Newton's attention.

[5] Newton 1672a; Jalobeanu 2015, chapter 8.

[6] See McGuire and Tamny 1983, pp. 12–13.

[7] In *Colours*, Boyle discusses leaf gold, *Lignum nephriticum*, and coloured glass in experiments 9, 10, and 11, respectively; see B 4 106–14.

In true Baconian style, Newton goes on to claim that 'the discourse it self will lead to divers Experiments sufficient for its examination', and after outlining one such experiment, he concludes with the following admonition: 'if any of the R. Society shall be so curious as to prosecute [like experiments], I should be very glad to be informed with what success: That, if any thing seem to be defective, or to thwart this relation, I may have an opportunity of giving further direction about it'.[8] Sir Robert Moray took up Newton's challenge here in his 'Some Experiments propos'd in relation to Mr. Newton's Theory of light', which soon appeared, with Newton's reactions to the proposed experiments, in the *Philosophical Transactions*.[9]

Meanwhile, Newton himself sent off a further contribution, in the form of a set of queries 'to be determin'd by Experiments', which were published in both English and Latin later in 1672. This too is entirely what one would expect in the context of a group of natural philosophers practising the new experimental philosophy, for, as we saw in Chapter 3, the use of queries was one of the hallmarks of the natural philosophical method promoted by the Royal Society through its journal.[10] Newton prefaces his queries with the claim: 'the proper Method for inquiring after the properties of things is, to deduce them from Experiments' (Newton 1672c, p. 5004). And he rounds off with the following methodological conclusion to the queries:

> To determine by Experiments these and such like *Quaere's* which involve the propounded Theory, seems the most proper and direct way to a conclusion. And therefore I could wish all objections were suspended, taken from *Hypotheses* of any other heads than these two: Of shewing the insufficiency of Experiments to determine these *Quaere's* or prove any other part of my Theory, by assigning the flaws and defects in my conclusions drawn from them; Or of producing other Experiments which directly contradict me. (Newton 1672c, p. 5005)

Likewise in his reply to Hooke's 'Considerations' of his original paper on the theory of light, Newton structures his opening comments with a section on the 'Practique part of Optiques' followed by a section on the 'Theorique part' before going on to criticise Hooke's hypothesis and address a series of queries. All of this sits naturally within the genre of experimental philosophy.[11]

[8] Newton 1672a, p. 3087.
[9] Newton 1672b.
[10] For Newton's use of queries, see Anstey 2004.
[11] See Hooke 1757 [1672]; Newton 1672d. Boyle was particularly fond of the distinction between the practical and theoretical parts of natural philosophy, which effectively maps onto the experimental and speculative distinction. See especially his essay of *c.* 1666 on 'The Mutual Assistance that the Practicall and Theoricall Parts of Naturall Philosophy may afford one another. Propos'd as a great Inducement to hope for considerable matters from Experimental Philosophy', B 13 350–5.

The prioritising of experiments (the term 'experiment' appears nine times in the English section of the published version of the queries), the decrying of the use of hypotheses, and the central role of queries all point to a Newton who is self-consciously embracing experimental philosophy. There was no need for him to declare himself as an experimental philosopher at this point: his advocacy of experiment and decrying of speculation could hardly have been more obvious.

What was less obvious to many of the virtuosi within Newton's ambit was another dimension to Newton's vision for natural philosophy, a dimension that would not be fully realised until the publication of the *Principia* in 1687. This was, in general terms, the aim of bolstering natural philosophical reasoning with the certainty of mathematical demonstration. Newton expressed this quite early in his optical lectures:

> Thus although colours may belong to physics, the science of them must nevertheless be considered mathematical, insofar as they are treated by mathematical reasoning. Indeed, since an exact science of them seems to be one of the most difficult that philosophy is in need of, I hope to show – as it were, by my example – how valuable mathematics is in natural philosophy. I therefore urge geometers to investigate nature more rigorously, and those devoted to natural science to learn geometry first. Hence the former shall not entirely spend their time in speculations of no value to human life, nor shall the latter, while working assiduously with an absurd method, fail to reach their goal. But truly with the help of philosophical geometers and geometrical philosophers, instead of the conjectures and probabilities that are being blazoned about everywhere, we shall finally achieve a natural science supported by the greatest evidence. (Newton 1984, pp. 87/9)

Similar sentiments, again in relation to optics, were expressed by Newton in a letter to Oldenburg in response to Hooke's theory of colours, though Oldenburg excised them from the version published in the *Philosophical Transactions*:

> the absolute certainty of a Science cannot exceed the certainty of its Principles. Now the evidence by which I asserted the Propositions of colours is in the next words expressed to be from *Experiments* & so but *Physicall*: Whence the Propositions themselves can be esteemed no more then *Physicall Principles* of a Science. And if those Principles be such that on them a Mathematician may determin all the Phænomena of colours that can be caused by refractions, & that by computing or demonstrating after what manner & how much those refractions doe separate or mingle ... I suppose the *Science of Colours* will be granted *Mathematicall* & as certain as any part of *Optiques*. (*Newton Corr.*, 1, pp. 187–8)

Yet Newton was never able to realise this dream of a mathematical science of optics. As Ducheyne has argued, for Newton the problems of celestial dynamics were far more amenable to mathematical analysis than the

problems of optics.[12] It was in this domain that he would discover and apply the 'mathematical principles of natural philosophy' that became the primary referent for the title of the *Principia*.

The *Principia* was to become the most important work of early modern experimental philosophy both in terms of its own scientific achievements and in terms of the new methodological terrain that it opened up for the practice of experimental philosophy. Yet its impact was not felt straightaway. To be sure, the end of Book Two provided a clutch of arguments against the Cartesian vortex theory,[13] which was coming more and more to be regarded as the archetypal speculative natural philosophical theory, and Locke listed Newton among the master builders of the present age – this is almost certainly owing to the latter's contribution to experimental natural philosophy.[14] Yet for many experimental philosophers, the *Principia* was an impenetrable work that was best left to the experts. Furthermore, the term *experimentalis philosophia* did not appear in the first edition of 1687, and there was little by way of explicit methodological content. Moreover, it ostensibly gave a prominent place to hypotheses.[15] All of this was to change with the publication of the second edition in 1713 in which we find, for the first time, Newton self-consciously identifying as an experimental philosopher. The process by which this came about is not immediately obvious and was in many respects vexed and, for Newton, emotionally fraught. The background to this pronounced change is, therefore, worth setting out in some detail. This will require us to examine the scope and nature of experimental pedagogy in the first three decades of the eighteenth century as well as the status of natural history.

4.2 Experimental Pedagogy in England and Scotland

By the turn of the century, the term 'experimental philosophy' had come to designate not only a method for acquiring knowledge of nature by the use of observation and experiment, but also the content of such investigations. In short, there were now courses, both public and university-based, on experimental philosophy. New professions of the experimental lecturer and the experimental demonstrator emerged, lecture courses and demonstrations were advertised, textbooks were published, and the first university chair in experimental philosophy was established. In fact, as early as 1696 a course in anatomy based upon experimental philosophy was advertised in the London

[12] Ducheyne 2012, chapter 4.

[13] Book II, Section 9, propositions 52 and 53, *Principia*, pp. 781–90.

[14] Locke *Essay*, 'Epistle to the Reader', pp. 9–10. Locke was well aware of Newton's arguments against the vortex theory; see Locke 1688 and Anstey 2011a, pp. 93–7.

[15] The review in the *Journal des sçavans* claimed that 'it is only by certain hypotheses that are for the most part arbitrary [*par des hypotheses qui sont la plupart arbitraires*]' that he explains the system of the world; Anon. 1688, p. 237.

papers. The physician John Gorman advertised in the *Post Man* and *Post Boy* a 'Course of Anatomy . . . grounded upon experimental Philosophy' commencing on 2 December 1696.[16] In 1700, an annual course in experimental philosophy was advertised at Salvator's College of the University of St Andrews, Scotland (Figure 4.1). James Duncan was to be the teacher.[17] Soon, courses of experimental philosophy were being advertised in Oxford and London. Moreover, academic posts in experimental philosophy began to appear. Of singular importance in this regard was the appointment of Roger Cotes, the famed editor of the second edition of Newton's *Principia*, to the Plumian Chair of Astronomy and Experimental Philosophy at Cambridge in 1707.

Public courses in experimental philosophy were widely advertised throughout the first three decades of the eighteenth century in newspapers and books. They were lecture series with experimental demonstrations, carried out in halls, coffee houses, private homes, and even small colleges and were to be attended by subscription. For example, the course offered by Thomas Watts and Benjamin Worster was 'performed' at the Academy for clerks in Little Tower Street, London from 1719.[18] In many cases, advertisements for a course appeared in more than one paper. For example, John Theophilus Desaguliers' first course delivered in London was advertised in the *Evening Post* on 30 December 1712 and in the *Daily Courant* on 7 January 1713.[19] It was a common practice for the lecturer to have a list of lectures and/or accompanying experiments printed on a single sheet or pamphlet. Desaguliers' generic form was printed so that new dates and prices could be inserted (see Figure 4.2). The lectures were normally illustrated with experimental demonstrations with the use of up-to-date instruments and techniques.

The *Oxford Intelligencer* of the year 1707 advertised 'A College or Course of Mechanical and Experimental Philosophy, performed by Mr. John Keill of Christ Church'. The emphasis here was on the performance of illustrative experiments, a point to which we will return later in this section.[20] Experimental philosophy was popularly thought to have originated in

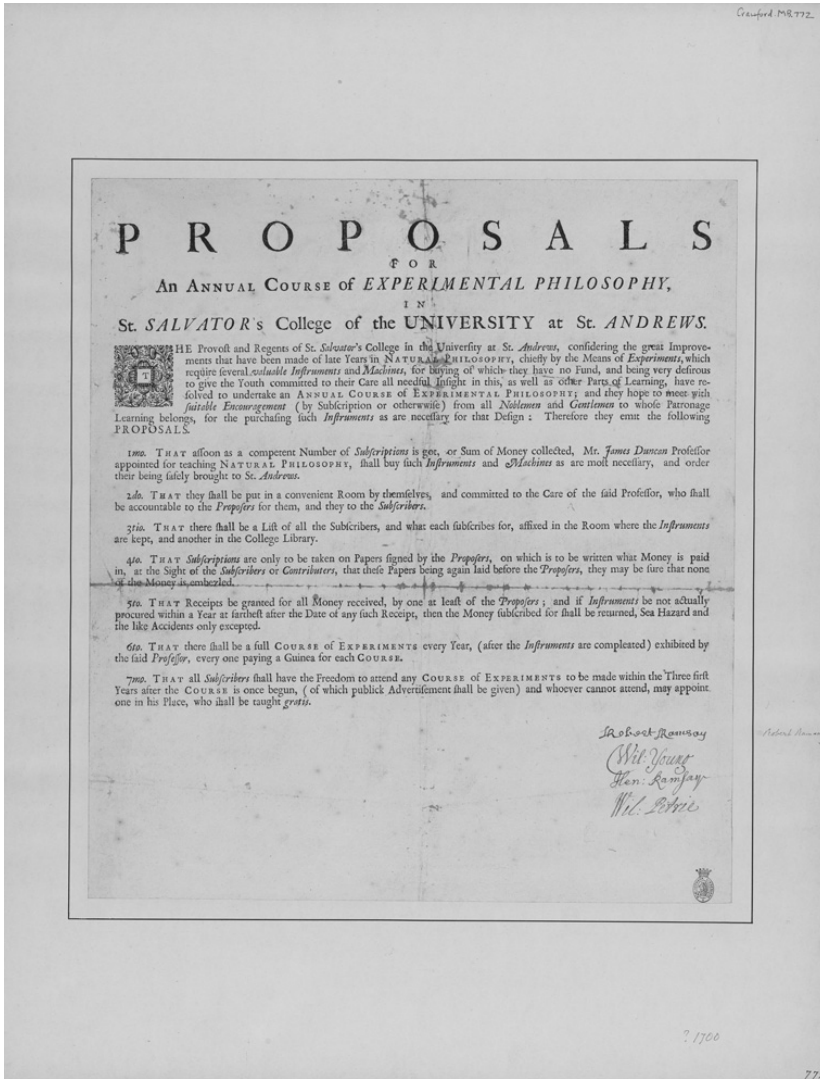
[16] Wigelsworth 2010, pp. 54–5.

[17] See Anon. 1700.

[18] For the Academy at Tower Street, see Worster 1722; Anon. 1727; Hans 1951, pp. 82–7; and Wigelsworth 2010, p. 61.

[19] See Carpenter 2011, pp. 28–9, *Daily Courant*, 7 January 1713; 'Advertisements and Notes', *Post Boy*, Issue 2756, 6–8 January 1713; see also Wigelsworth 2010, p. 59. Later that year, Desaguliers also advertised in *Pax, Pax, Pax, or a Pacific Post Boy*, Issue 2807, 5–7 May 1713 promising a catalogue of experiments, and 'Advertisements', *The Examiner*, 27–30 November 1713, claiming that his subjects were 'demonstrated and proved, by more than 300 Experiments'. For a general treatment of public lectures in natural philosophy at this time, see L. Stewart 1992.

[20] *Mercurius Oxoniensis; or, The Oxford Intelligencer*, 1707, pp. 30–1.



PROPOSALS

FOR

An ANNUAL COURSE of *EXPERIMENTAL PHILOSOPHY*,

IN

St. *SALVATOR*'s College of the UNIVERSITY at St. *ANDREWS*.

THE Provoſt and Regents of St. *Salvator*'s College in the Univerſity at St. *Andrews*, conſidering the great Improvements that have been made of late Years in NATURAL PHILOSOPHY, chiefly by the Means of *Experiments*, which require ſeveral *valuable Inſtruments* and *Machines*, for buying of which they have no Fund, and being very deſirous to give the Youth committed to their Care all needful Inſight in this, as well as other Parts of Learning, have reſolved to undertake an ANNUAL COURSE of EXPERIMENTAL PHILOSOPHY; and they hope to meet with *ſuitable Encouragement* (by Subſcription or otherwiſe) from all *Noblemen* and *Gentlemen* to whoſe Patronage Learning belongs, for the purchaſing ſuch *Inſtruments* as are neceſſary for that Deſign: Therefore they emit the following PROPOSALS.

1mo. THAT aſſoon as a competent Number of *Subſcriptions* is got, or Sum of Money collected, Mr. *James Duncan* Profeſſor appointed for teaching NATURAL PHILOSOPHY, ſhall buy ſuch *Inſtruments* and *Machines* as are moſt neceſſary, and order their being ſafely brought to St. *Andrews*.

2do. THAT they ſhall be put in a convenient Room by themſelves, and committed to the Care of the ſaid Profeſſor, who ſhall be accountable to the *Propoſers* for them, and they to the *Subſcribers*.

3tio. THAT there ſhall be a Liſt of all the Subſcribers, and what each ſubſcribes for, affixed in the Room where the *Inſtruments* are kept, and another in the College Library.

4to. THAT *Subſcriptions* are only to be taken on Papers ſigned by the *Propoſers*, on which is to be written what Money is paid in, at the Sight of the *Subſcribers* or *Contributers*, that theſe Papers being again laid before the *Propoſers*, they may be ſure that none of the Money is embezled.

5to. THAT Receipts be granted for all Money received, by one at leaſt of the *Propoſers*; and if *Inſtruments* be not actually procured within a Year at fartheſt after the Date of any ſuch Receipt, then the Money ſubſcribed for ſhall be returned, Sea Hazard and the like Accidents only excepted.

6to. THAT there ſhall be a full COURSE of EXPERIMENTS every Year, (after the *Inſtruments* are compleated) exhibited by the ſaid *Profeſſor*, every one paying a Guinea for each COURSE.

7mo. THAT all *Subſcribers* ſhall have the Freedom to attend any COURSE of EXPERIMENTS to be made within the Three firſt Years after the COURSE is once begun, (of which publick Advertiſement ſhall be given) and whoever cannot attend, may appoint one in his Place, who ſhall be taught *gratis*.

Robert Ramſay
Wil. Young
Hen: Ramſay
Wil. Petrie

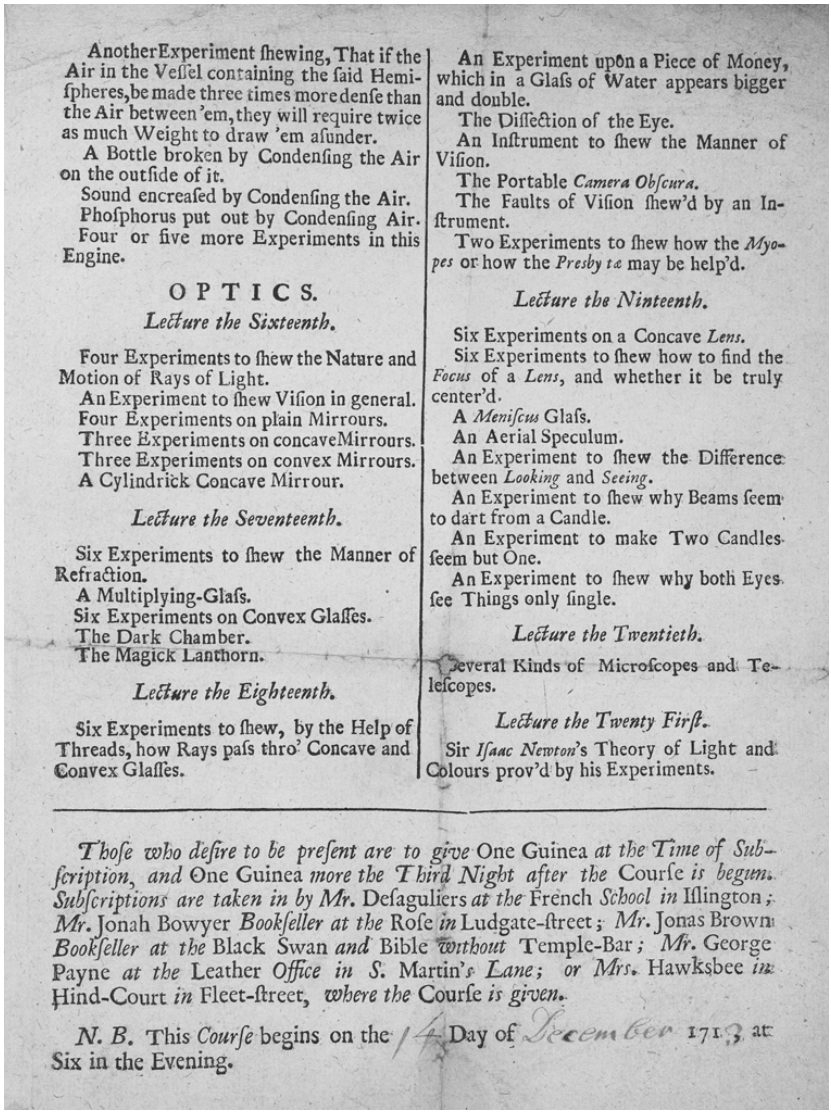
Crawford MS 772

? 1700

772

Figure 4.1 Proposals for an annual course in experimental philosophy at St Salvator's College, University of St Andrews, Scotland, 1700. Reproduced with permission from materials on loan to the National Library of Scotland by the Balcarres Trust

England in the writings of Bacon and/or Boyle and then spread to the Continent. Moreover, it was said to have emerged as a result of its progenitors' ability to avoid the vice of prepossession. It was often pitted against or, at least in relation to speculative philosophy, and said to have made great strides in



Another Experiment ſhewing, That if the Air in the Veſſel containing the ſaid Hemiſpheres, be made three times more denſe than the Air between 'em, they will require twice as much Weight to draw 'em aſunder.

A Bottle broken by Condenſing the Air on the outſide of it.

Sound encreaſed by Condenſing the Air.

Phoſphorus put out by Condenſing Air.

Four or five more Experiments in this Engine.

OPTICS.

Lecture the Sixteenth.

Four Experiments to ſhew the Nature and Motion of Rays of Light.

An Experiment to ſhew Viſion in general.

Four Experiments on plain Mirrours.

Three Experiments on concave Mirrours.

Three Experiments on convex Mirrours.

A Cylindrick Concave Mirrour.

Lecture the Seventeenth.

Six Experiments to ſhew the Manner of Refraction.

A Multiplying-Glaſs.

Six Experiments on Convex Glaſſes.

The Dark Chamber.

The Magick Lanthorn.

Lecture the Eighteenth.

Six Experiments to ſhew, by the Help of Threads, how Rays paſs thro' Concave and Convex Glaſſes.

An Experiment upon a Piece of Money, which in a Glaſs of Water appears bigger and double.

The Diſſection of the Eye.

An Inſtrument to ſhew the Manner of Viſion.

The Portable *Camera Obſcura*.

The Faults of Viſion ſhew'd by an Inſtrument.

Two Experiments to ſhew how the *Myopes* or how the *Presbytæ* may be help'd.

Lecture the Ninteenth.

Six Experiments on a Concave *Lens*.

Six Experiments to ſhew how to find the *Focus* of a *Lens*, and whether it be truly center'd.

A *Meniſcus* Glaſs.

An Aerial Speculum.

An Experiment to ſhew the Difference between *Looking* and *Seeing*.

An Experiment to ſhew why Beams ſeem to dart from a Candle.

An Experiment to make Two Candles ſeem but One.

An Experiment to ſhew why both Eyes ſee Things only ſingle.

Lecture the Twentieth.

Several Kinds of Microſcopes and Teleſcopes.

Lecture the Twenty Firſt.

Sir *Iſaac Newton*'s Theory of Light and Colours prov'd by his Experiments.

Thoſe who deſire to be preſent are to give One Guinea *at the Time of Subſcription, and* One Guinea *more the Third Night after the* Courſe *is begun. Subſcriptions are taken in by Mr.* Deſaguliers *at the* French *School in* Iſlington; *Mr.* Jonah Bowyer *Bookſeller at the* Roſe *in* Ludgate-ſtreet; *Mr.* Jonas Brown *Bookſeller at the* Black Swan *and* Bible *without* Temple-Bar; *Mr.* George Payne *at the* Leather *Office in S.* Martin's *Lane; or Mrs.* Hawksbee *in* Hind-Court *in* Fleet-ſtreet, *where the* Courſe *is given.*

N. B. This *Courſe* begins on the 14 Day of December 1713, at Six in the Evening.

Figure 4.2 The final page of Desaguliers' *A Catalogue of the Experiments in Mr Desaguliers's Course*, 1713. Used with permission of the British Library

recent years. Finally, it was also beginning to be appealed to in defences of natural religion.[21]

[21] See Anstey 2017b.

As for the content of these courses, the standard syllabus was as follows. Courses normally opened with some methodological remarks and some general conceptual commitments about the nature of matter and motion. The first topic to be addressed was mechanics, which dealt with the laws of motion and with the principles of simple machines. Next came hydrostatics, followed by pneumatics and optics. In fact, the mechanics–hydrostatics–pneumatics–optics format was very widely adopted.[22] In addition, as we saw with the very early course of John Gorman, there were other approaches. Some courses attempted to teach anatomy according to the method of experimental philosophy, others chymistry, and still others astronomy. None of these disciplines, however, became central to the pedagogy of experimental philosophy, and some of the leading experimental pedagogues offered courses in both experimental philosophy and astronomy, as if the latter was not strictly part of the experimental philosophy syllabus. There were also courses that were really only series of experimental demonstrations of striking phenomena or of recent natural philosophical advances. As we shall see later in this section, some experimental pedagogues did not regard these courses as genuine courses in experimental philosophy.

The first university lectures in experimental philosophy are normally attributed to John Keill at Oxford.[23] His course is advertised in *The Oxford Almanack* of 1703.[24] There is evidence, however, in an extract from a lost life of John Harris, the editor of the *Lexicon Technicum*, that lectures on experimental philosophy may have been given at Trinity College Oxford as early as the 1680s. It is related that:

> Lectures were here [at Trinity] read in Experimental Philosophy and Chymistry, and a very tolerable course of Mathematicks taught: especially after Harris took his first degree. (Blakiston 1898, p. 173)

Harris graduated BA in 1684 and if the lectures in experimental philosophy roughly coincided with his mathematical lectures, then they may have begun in the 1680s. The college was then presided over by Ralph Bathurst, who had been associated with the founding of the Royal Society decades earlier and who was well known for his promotion of natural philosophy.

University courses in experimental philosophy were given at both Oxford and Cambridge. At Oxford they were by subscription and were supplementary

[22] See, for example, the course advertisements in note 19 above.

[23] Desaguliers recalled in the 1730s, wrongly, that Keill was the first to give lectures in the subject around 1704–5. See Desaguliers 1734, sig. c^{r}. It is not clear that Keill's early lectures are best characterised as lectures on experimental philosophy. See Anstey 2015, pp. 118–20 for further discussion. Moreover, Keill's lectures did not contain material on simple machines. Desaguliers claims that he added a section on mechanics when he took over from Keill at Oxford; see Desaguliers 1734, sig. c^{r}.

[24] *The Oxford Almanack for the Year of our Lord God 1703*, pp. 5–6.

to the regular curriculum. There was an almost uninterrupted chain of instruction in experimental philosophy at Oxford from c. 1703 until 1760. This was in spite of the fact that, unlike at Cambridge University, there was no chair in experimental philosophy. The lecturers and the dates of their courses are shown in Table 4.1. The lectures of Whiteside and Bradley survive in manuscript. The lectures of Keill and Desaguliers were published.[25]

At Cambridge, the first lectures in experimental philosophy, according to William Whiston, were given by Cotes and Whiston and commenced on 5 May 1707, just a few months before Cotes was installed as the Plumian Professor of Astronomy and Experimental Philosophy.[26] An autograph version of Cotes' early lectures survives in the Bodleian Library and covers hydrostatics and pneumatics.[27] Interestingly, the manuscript opens with lectures on mechanics that bear some close parallels with those of Keill. It is not clear whether they formed part of Cotes' lectures, though together with the lectures in Cotes' hand they form the standard mechanics–hydrostatics–pneumatics progression with only optics missing. In the very same year, an eight-page pamphlet entitled *Ἐνκυκλοπαιδεία or, A Method of Instructing Pupils. 1707*, by Robert Greene of Clare College Cambridge, prescribes 'Experimental Philosophy, and Chymistry' as the first thing to be studied in the period from Christmas to the Commencement. Suggested reading comprises 'Philos. Transact. Leipsick Acts, Boyle, Lemmery, Collegium Curiosum' (Greene 1707, p. 3).[28] This was to follow the study of, *inter alia*, metaphysics and corpuscular philosophy in the second year.[29] Lectures in experimental

Table 4.1 *Lecturers in experimental philosophy at the University of Oxford*

John Keill	1703–9
John Theophilus Desaguliers	1710–13[30]
John Whiteside	1714–28
James Bradley	1729–63
Thomas Hornsby	1763–1810

[25] For an analysis of the different versions of Desaguliers' lectures before 1720, see Anstey 2015.
[26] Whiston 1753, p. 118.
[27] Bodleian Add. MS C. 272.
[28] The prescribed texts are: *Philosophical Transactions of the Royal Society*, *Acta Eruditorum* published in Leipzig, Boyle's chymical works, Nicolas Lémery's *A Course of Chymistry*, of which there were multiple English editions from 1677, and Johann Sturm's *Collegium experimentale sive curiosum*, which appeared in 1676 and 1685.
[29] Greene 1707, p. 2.
[30] See Desaguliers 1734, sig. c^{v}.

philosophy continued in Cambridge through the 1740s and 1750s, such as those given by William Powell, whose *Heads of a Course of Lectures in Experimental Philosophy* reveal that he included astronomy after the lectures on mechanics.[31]

It is important, therefore, that we determine exactly what these different pedagogues considered experimental philosophy to be and how this was related to the methodology that Newton claimed to have pursued in the second edition of his *Principia*. A good place to begin is with Desaguliers' extended discussion in the preface to the first volume of his *A Course of Experimental Philosophy*, first published in 1734. After a quarter of a century of lecturing in experimental philosophy, Desaguliers had become the elder statesman in the field with a substantial international reputation. He notes in the preface that he is currently teaching his 121st course in experimental philosophy, and 'of eleven or twelve Persons, who perform Experimental Courses at this time in England, and other Parts of the World, I have had the Honour of having Eight of them for my Scholars' (Desaguliers 1734, sig. c^{v}). Desaguliers' reflections are a useful guide as to his understanding of the nature of experimental philosophy and its history. His contrast between Keill's and Francis Hauksbee's lectures provides a good starting point:

> Dr *John Keill* . . . laid down very simple *Propositions*, which he prov'd by *Experiments*, and from those he deduc'd others more compound, which he still confirm'd by Experiments; till he had instructed his Auditors in the *Laws of Motion*, the *Principles of Hydrostaticks* and *Opticks*, and some of the chief *Propositions* of Sir *Isaac Newton* concerning *Light* and *Colours*. . . . There were indeed, about the same time, *Experiments* shewn at *London* by the late Mr. *Hauksbee* . . . But as they were only shewn and explain'd as so many curious *Phaenomena*, and not made Use of as *Mediums* to prove a Series of philosophical Propositions in a mathematical Order, they laid no such Foundation for true Philosophy as Dr. *Keill's Experiments* . . . *They were Courses of Experiments*, and his [Keill's] a *Course of Experimental Philosophy*.
>
> (Desaguliers 1734, sig. c^{r})

The last sentence here is telling: Hauksbee's lectures were 'Courses of Experiments' whereas those of Keill were 'a Course of Experimental Philosophy'. The difference is in the role that experiments played in establishing a series of natural philosophical principles. Where Keill established simple propositions by experiments and from them deduced 'others more compound' but also confirmed by experiments, Hauksbee only showed and explained many curious 'electrical, hydrostatical, and pneumatical' phenomena, no doubt with the use of his air pump and other instruments.

[31] See Powell 1746 and 1753. For public lectures in experimental philosophy in London from 1750 to 1765, see Morton 1990.

There are four constituents to Desaguliers' conception of experimental philosophy: natural philosophical principles, the application of mathematics, demonstrative reasoning, and experiments. What is important here is Desaguliers' understanding of the interplay of principles, demonstrative reasoning, and experiments. It is not as if he is claiming to be producing new knowledge in his lectures, but rather to show the method by which new natural philosophical knowledge had been produced by the likes of Newton. Earlier in the preface, Desaguliers is more explicit about the role of mathematics:

> All the Knowledge we have of Nature depends upon Facts; for without Observations and Experiments, our natural Philosophy would only be a Science of Terms and an unintelligible Jargon. But then we must call in Geometry and Arithmetick to our Assistance, unless we are willing to content our selves with natural History and conjectural Philosophy. For, as many Causes concur in the Production of compound Effects, we are liable to mistake the predominant Cause, unless we can measure the Quantity of the Effects produc'd, compare them with, and distinguish them from each other, to find out the adequate Cause of each single Effect, and what must be the Result of their joint Action. (Desaguliers 1734, sig. b^{r})

Desaguliers starts with observation and experiment and then brings mathematics to bear in order to quantify effects with a view to determining predominant causes and distinguishing them from others among the compound causes of the phenomenon at hand. He goes on to give the examples of the motion of the moon and tides, and the shape of the Earth. Two further points are worthy of note from the preface. First, we should note the aligning of natural history with conjectural, that is, speculative natural philosophy. There are hardly any references to natural history in the textbooks and lecture outlines of courses in experimental philosophy from Keill on. It is striking, therefore, that when Desaguliers does mention natural history, it is only to lump it with speculative philosophy. This, we suggest, reflects the dramatic fall from grace of natural history in British experimental philosophy to which we shall return in Section 4.5 below.

Second, we need to note the centrality of 'the Newtonian Philosophy' here. After dismissing the early attempts of Descartes and the Cartesians who 'fancied they could solve all Appearances mechanically by Matter and Motion' as a 'philosophical Romance ... that required no Mathematicks to understand it', Desaguliers proceeds to Newton's method:

> It is to Sir *Isaac Newton's* Application of Geometry to Philosophy, that we owe the routing of this Army of *Goths* and *Vandals* [the Cartesians] in the philosophical World ... Before Sir *Isaac*, we had but wild Guesses at the Cause of the Motion of the Comets and Planets round the Sun; but now he has clearly deduc'd them from the universal Laws of Attraction. (Desaguliers 1734, sig. b^{r-v})

It may be objected that all of this is rather abstract, but Desaguliers can rightly claim that it is amply illustrated in the hundreds of pages of lectures and experimental descriptions that follow and, of course, the experimental demonstrations that accompany the teaching of the course.

Another gifted experimental pedagogue was Roger Cotes. We will discuss his broader conception of experimental philosophy in our treatment of his preface to the second edition of Newton's *Principia* in Section 4.4. There are, however, some curious features of Cotes' writings that are worth considering at this juncture. First, the term 'experimental philosophy' is hardly used in the autograph version and fair copies of Cotes' (and Whiston's) early lectures or the posthumous published version.[32] Of course, Cotes held the Chair of Astronomy and Experimental Philosophy, yet it is striking that the term is used so rarely in his lectures. It is also interesting to note that Cotes' co-lecturer, Whiston, calls them a 'course of philosophical experiments' (Whiston 1753, p. 118). Likewise, Cotes' cousin, Robert Smith, who took over the lectures and the Chair of Astronomy and Experimental Philosophy when Cotes died in 1716 and eventually published the lectures, describes them in these terms:

> As to the method in general of teaching Philosophy by Courses of Experiments, (that is, of drawing general truths and conclusions from a select number of simple experiments, first represented to our senses, and then explained to our understandings,) it is now so much practised and approved by the most eminent Professors all over Europe, and has so greatly contributed to the propagation and increase of knowledge . . . that nothing more need be said to shew the usefulness and excellency of it.
>
> (R. Smith, Preface, Cotes 1738, sig. A3^{v})

What we find in Cotes' lectures is that experiments are given pride of place over theory. Each lecture begins with one or more experiments from which natural philosophical conclusions are drawn and elaborated upon. Take, for example, Cotes' second lecture on hydrostatics. After a summary of the first lecture he begins, 'I design this day to make some farther experiments concerning the pressure of fluids, by which I shall endeavour to demonstrate some of its more general effects' (Cotes 1738, p. 10).

The priority of experiment arises from Cotes' view of the power of inductive generalisations from experiments. In the opening of his lectures on

[32] For occurrences of 'Experimental Philosophy' in Cotes and Whiston's lectures, see Beineke Library Osborn fc95, p. 140 and University of Manchester Library GB 133 Eng MS 1494, fol. 64^{v}.

hydrostatics, he expresses this with a principle similar to Newton's Third Rule and words echoing the opening sentence of the *Opticks*:

> Whatsoever can be prov'd by reason and Experiments to belong to any one body which is both Fluid and Heavy, upon account of its being fluid and heavy, must belong to all other bodies which are fluid and heavy.
>
> If due caution be observ'd we may very safely be allow'd to draw general conclusions from Experiments which cannot otherwise be made but upon particular bodies. (Bodl. Add. MS C.272, p. 61 = Cotes 1738, p. 4)[33]

Interestingly, John Whiteside, who lectured in experimental philosophy from *c.* 1714 to 1729 at Oxford, opens his lectures on hydrostatics with the same words. Indeed, Whiteside's lectures are identical to the lectures in Bodl. Add. MS C.272, including Cotes' early lectures on hydrostatics and pneumatics. That is to say, Whiteside's Oxford lectures that are now in Cambridge are identical to Cotes' early Cambridge lectures that are now in Oxford! Robert Smith claims in the preface to the published version of Cotes' lectures, 'the Lectures were frequently lent out to be transcribed', and it is clear that one such transcription formed the basis of Whiteside's Oxford course.[34] In the 1720s, Whiteside offered a twenty-four-day course which also included two lectures on architecture, one on magnetism, and one on astronomy.[35]

James Bradley (*c.* 1692–1762) was one of the leading English astronomers of the eighteenth century, being appointed to the Savilian Chair in Astronomy at Oxford in 1721 on the death of John Keill, before being appointed as Astronomer Royal in 1742 on the death of Edmund Halley. He announced his discovery of the phenomenon of nutation in the movement of the Earth in 1748 and was subsequently awarded the Royal Society's Copley Medal. Our interest in Bradley, however, lies in his teaching of experimental philosophy at Oxford for over thirty years. Bradley gave a staggering seventy-nine (at least) courses on experimental philosophy from 1729 to 1760.

A register of all those who attended Bradley's lectures from April 1746 to April 1760 survives and shows the name and college affiliation of every student who attended.[36] The courses averaged fifty-seven students. The lectures were given in the Old Ashmolean Museum. Happily, many of Bradley's lecture notes survive in the Bodleian Library. Since there was no chair in experimental philosophy at Oxford, Bradley had to secure some source of income for his lectures. We know that for his last thirty-three courses he charged two guineas

[33] Newton opens the 1704 edition of the *Opticks* thus: 'My Design in this Book is not to explain the Properties of Light by Hypotheses, but to propose and prove them by Reason and Experiments', p. 1.

[34] A copy of Cotes' later lectures survives at King's College London in the Foyle Special Collections Library, Wheatstone Collection QC19 COT.

[35] See Bodl. MS Bradley 48, fols. 1–2.

[36] It is reproduced as appendix E of volume XI of Gunter 1923–45.

for the first lecture and one guinea for the second lecture. It must have been a handy little earner. According to the *Memoirs of Bradley* (Bradley 1832, p. xxxviii), thirty-one pounds had been set aside each year for a reader in experimental philosophy by convocation in 1731 from the estate of the late Bishop of Durham, Nathaniel Crewe, but Bradley did not see any of this money until 1749.

Bradley's lectures were similar in content to those of Desaguliers and of Roger Cotes and William Whiston in Cambridge. The syllabus remained fairly static for sixty years. It included the laws of nature, mechanics, hydrostatics, pneumatics, and optics. The teaching of experimental philosophy had come a very long way from the emergence of experimental philosophy in the 1660s to the time that an average of over fifty undergraduates were signing up for courses in it from 1746. One of the most interesting features of Bradley's lectures is the manner in which the distinction between experimental and speculative philosophy is presented at the very beginning of his opening lecture. Bradley commences with a general reference to the laws of nature: 'these are no otherwise to be discovered than by experiments & observation & examining the Phaenomena & finding from them by what laws their motions are ordered & regulated. which is properly the Business & scope of Natural & Experimental Philosophy' (Bodleian Library MS Bradley 1, pp. 1–2).

This view of natural philosophy is interesting insofar as it places laws of nature and experiment to the fore in a manner that was not possible before the advent of Newton's *Principia*. Bradley continues:

> But then our principal endeavour must be to learn the true & real manner in which the operations of Natur are actually performd & not content ours[elves] with framing Hypoth[eses] to explain how such Phaenom[ena] may be perform'd tis on this account that Reasoning much from Hypotheses in Natural Phil[osophy] is apt to lead people into mistakes and there is no likelier a method [to] avoid error than having recourse to experiments & trials. (Bodl. MS Bradley 1, p. 2)[37]

Note here the rhetoric of experimental philosophy: the warning against 'framing Hypotheses' which can lead to error, and the emphasis on experiment and observation. Bradley then expresses a form of fallibilism in his claims about the epistemic status of knowledge acquired by the method of 'experiments & trials':

> Tho this is no doubt the most likely method of coming at the truth yet even in this manner of proceeding we must not expect to meet with Proof in Natural Philosophy so absolutely convincing as in pure mathematics because the Ideas we have to do with in Mathematics are the Productions

[37] This section of Bradley's lecture was paraphrased by his successor as Reader in Experimental Philosophy at Oxford, Thomas Hornsby. See Bodl. MS Radcliffe Trust d. 9, fol. 32, transcribed in Jim Bennett 2013, p. 75.

> of the mind itself & therefore we may have a more full adequate knowledge of them than of those we have in natural Philosophy which being fram'd from things without us they may not be just & consequently our deductions & reasonings about these may be liable to some uncertainty & leave some scruple upon the mind. (Bodl. MS Bradley 1, p. 3)

Bradley is honest in his claim that one should not expect mathematical certainty in matters of experimental natural philosophy. Yet he also believes that there are measures that one can take to assure us that our inferences from experiments are secure: 'In order to remove all scruple as much as possible & that the mind may assent to the conclusions drawn from facts & experiments in searching into the operations of nature Sir I. Newton lays down the following Rules of Arguing in Natural Philosophy' (Bodl. MS Bradley 1, p. 3). He then summarises the four rules of philosophising that Newton first published in the third edition of the *Principia*. What Bradley is providing in his very first lecture is a methodological statement that reveals his conception of experimental philosophy as a means by which one acquires the knowledge of nature. This is what generations of students were taught at Oxford when they enlisted in his courses in the Old Ashmolean Museum. Here is how one student recorded the opening of Bradley's first lecture in 1747:

> After enlarging upon the Excellency of the present experimental Philosophy, if compar'd with the uncertain state it was some time ago in, when Conclusions were in a great measure drawn from Conjecture & Hypothesis; Dr Bradley told us, that in treating of natural Bodies he should consider them with regard to their natural Phaenomena, or Effects discoverable by the senses alone, & their natural Properties or Qualities which have been constantly found inherent in all Bodies that have fall'n under the human Observation. He then mentioned 3 Rules laid down by Sir Isaac Newton, as proper to be observed by all who are desirous of making any Proficiency in natural knowledge.
>
> (Bodl. MS Bradley 12, p. 4)[38]

There is no doubt that the proliferation of courses in experimental philosophy and demonstrations both in the universities and in public heralded the success and legitimacy of this new approach to the study of nature. It should not be thought, however, that experimental philosophy swept all before it. In the first edition of his *Cyclopaedia* published in 1728, Ephraim Chambers wrote in his entry on 'Experimental Philosophy':

> Experimental Philosophy . . . is that which proceeds on *Experiments*; or which deduces the Laws of Nature, and the Properties and Powers of Bodies, and their Actions upon each other, from sensible *Experiments* and Observations.

[38] Interestingly, Bradley is called 'Savilian Professor of Astronomy & Reader in Experimental Philosophy', Bodl. MS Bradley 12, p. 4.

> In Effect, *Experiments,* within these 50 or 60 Years, are come into such Vogue, that nothing will pass in Philosophy, but what is founded on *Experiments*, or confirm'd by *Experiment*, &c. So that the new Philosophy is almost altogether *Experimental*. (Chambers 1728, p. 368)

Yet Chambers' article goes on to list a number of criticisms of experimental philosophy, stressing that the movement was not without its detractors.[39] Many educated people with an interest in natural philosophy acknowledged its impact and importance, yet some were less convinced about its institutional status. The common lawyer and writer, Roger North, is a good example. In his musings on 'Authoritys', written some time after the publication of the second edition of Newton's *Principia* in 1713, he turns to experiment. After dismissing the older Aristotelian approach to authority, he claims:

> So that the new philosophers appealed to experiment as the [Protestant] reformers did to a generall councell, as they thought an authority superior to that which opprest them. And herein they were in the right, for dispute, on the chican[e] of which old philosofy leaned, vanish't, issue was joyned, & a verdit by tryall decided all.
>
> This notorious benefit of experiments, when the world was inclined to chang[e], put them so much in credit that ever since nothing is talked of but experiment, and societys are founded for that end, their motto Nullius in verba, the designe to make such a body of experiments, as shall serve to build a fabrick of naturall philosofy, such as time shall neither improve nor destroy. I must confess if there were the same zeal in the carrying on these designes as first promoted the institutions [then] great benefit might be had, & considerable discoverys made, but after the chang[e,] for which experimentall philosofy was cryed up, is made & setled, the proceedings of these incorporate societys flagg, and the readers, & president's places, goe by favour and their performances, meer lip-labour.
>
> (British Library Add. MS 32546, fols. 229–30)[40]

North is clearly somewhat ambivalent about the current practice of experimental philosophy as promoted by the Royal Society, even though he regards it as a very important development in natural philosophical methodology.

4.3 John Keill's Attractionism

If North was slightly ambivalent, the Newtonian John Keill was openly critical. Keill had launched himself on the scene in 1698 with his forthright criticisms of Thomas Burnet's and John Woodward's speculative theories of the

[39] In fact, Chambers' article is heavily dependent upon John Keill's comments on experimental philosophy in his *Introduction* of 1720, which reflects Keill's criticisms of experimental philosophy around 1700. For further discussion, see Section 4.3 below.

[40] Transcription provided by Jamie Kassler. 'Lip-labour' means empty talk, OED.

formation of the Earth.[41] While criticising Thomas Burnet and John Woodward, he famously castigated Descartes and the Cartesians for the failures of the vortex theory. Descartes' great failing came down to this: in spite of all of his rhetoric, he failed entirely to apply mathematics to his cosmology and cosmogony:

> So far was *Des Cartes* from Marrying Physicks with Geometry, that it was his great fault that he made no use at all of Geometry in Philosophy. . . . [Descartes] was so far from applying Geometry and observations to natural Philosophy, that his whole System is but one continued blunder upon account of his negligence in that point. (Keill 1698, pp. 15–16)

Yet even though he was an exponent of Newton's natural philosophy, he saw no reason to support experimental philosophy. In his introduction, he lists four current sects of philosophers: the Pythagoreans and Platonists, the Peripatetics, those 'such as proceed upon Experiments', and the mechanical philosophers. All of them have their faults, and 'there is no particular one, wherein we do intirely acquiesce'. The problem with the experimental philosophers is that they have 'too often distorted their Experiments and Observations, in order to favour some darling Theories they had espoused' (Keill 1720, p. 3).[42] Keill is not opposed to experiment but is cautious because 'we are well apprised how fond these Gentlemen [the experimental philosophers] are of their Theories, how willing they are that they should be true, and how easily they deceive both others and themselves in trying their Experiments' (Keill 1720, p. 7). Clearly Keill does not view the ESD as would a typical experimental philosopher, and his criticism here is reminiscent of that of Margaret Cavendish in the 1660s.

What is important for our story, however, is not Keill's criticism of experimental philosophy, but the nature of his alternative. For what he presents is, in effect, a fully fledged corpuscular natural philosophy, the centrepiece of which is a new theory of material qualities based upon an analogue of the inverse square law of gravitational attraction. In Lecture VIII, Keill claims that we should not expect a demonstrative science of nature with the same degree of certainty as we find in geometry, yet, nevertheless, through reason and experience we can develop a theory that will 'exhibite Propositions that are not absolutely true, but nearly approaching to the Truth' (Keill 1720, p. 88). He then goes on to set out a series of axioms and to discuss various phenomena, including the forms and qualities of bodies that arise from their motions and the arrangements of their parts.[43] It is clear that he regards this as a form of

[41] See Burnet 1681; Woodward 1695.

[42] Keill may well have Boyle in mind, for he mentions 'they are wont to be called *Mechanical*' thinking they can explain everything by 'Matter and Motion, by the Figure and Texture of the Parts' (John Keill 1720, p. 3).

[43] Keill 1720, pp. 89–98.

mechanical philosophy, in spite of his reservations about mechanism expressed in the opening chapter. He then turns from those forms and qualities that are subject to mechanical explanations to intensive qualities. He provides a principle that applies to all of these qualities, and this is absolutely crucial for understanding the provenance and content of the kernel of Keill's natural philosophy. It is also of great relevance to Newton's subsequent open adherence to experimental philosophy as will soon become apparent. Keill's Latin has:

> Ex dictis sequitur, qualitates corporum, quae a formis non pendent, quaeque eadem manente materiae qualitate intendi & remitti nequeunt, sed omnibus insunt corporum generibus, in quibus experimenta instituere liceat, esse qualitates omnium corporum universales.
>
> (Keill 1702, pp. 84–5)[44]

If we compare this with Newton's third rule of philosophising in the second edition of the *Principia*, the parallels (underlined in both extracts) are striking:

> Qualitates corporum quae intendi & remitti nequeunt, quaeque corporibus omnibus competunt in quibus experimenta instituere licet, pro qualitatibus corporum universorum habende sunt.
>
> (Newton 1713, p. 357)[45]

Clearly, Keill had access to a later version of Newton's revisions to Book Three, because his 'rule' is closer to the version in Newton's interleaved first edition of the *Principia* than, say, the version published by Gröning in 1701, which lacks the clause pertaining to qualities not intending and remitting.[46] What he has done in his *Introductio* is to incorporate a slightly adapted version of Newton's draft third rule, a rule that would not be published for another eleven years, directly into his eighth lecture.[47]

[44] 'From what has been said, it follows, that the Qualities of Bodies which do not depend on their Forms, and which, the Quantity of Matter remaining the same, are not increased or remitted, but are in all sorts of Bodies upon which we can make any Experiments; are the universal Qualities of all Bodies', Keill 1720, p. 100.

[45] 'Those qualities of bodies that cannot be intended and remitted and that belong to all bodies on which experiments can be made should be taken as qualities of all bodies universally', *Principia*, p. 795.

[46] See Gröning 1701, p. 114. Keill's source is unlikely to have been his Oxford colleague David Gregory, for his 'Notae' on the *Principia* contain the early version of Rule III which is identical, though with slightly different commentary, to that in Gröning 1701, which derives from Christiaan Huygens. See Christ Church MS 131, p. 175. For discussion of the various versions of Rule Three, see Cohen 1966 and 1971, pp. 24–6; McGuire 1968.

[47] McGuire (1968, p. 238) wrongly claims that Keill is paraphrasing the version that derives from Huygens, for that version does not contain the crucial clause 'quae intendi et remitti nequeunt'. This clause does occur in the annotation to Hypothesis III in Locke's copy of the *Principia*, which he received from Newton in 1691. See Cohen 1971, p. 24.

This principle, in turn, when combined with an inverse square law, provided Keill with the materials for a new theory of qualities as elaborated in Lecture 1. There, he claims to demonstrate the following theorem: 'Every Quantity or Virtue, that is propagated every way in right lines from a Center, is diminished in a duplicate Proportion of the Distance from that Center' (Keill 1720, p. 5). He claims to have demonstrated this theorem and that it applies to a range of qualities:

> We have demonstrated this Theorem universally, whatever is the Nature of the Quality, so that it acts in right lines; and hence it follows, that the Intensions of Light, Heat, Cold, Perfumes, and the like Qualities, will be reciprocally as the Squares of their Distances from the Point whence they proceed. Hence also may be compared amongst themselves, the Actions of the Sun on different Planets: but this is not the Business of our present Design. (Keill 1720, pp. 6–7)

What Keill has done is to generalise Newton's result for gravity and apply an inverse square law to all qualities that undergo intension and remission. Keill is extending the determinate law of nature that pertains to one quality, gravity, to other qualities in order to explain their intension and remission.[48] Furthermore, it seems highly likely that the inspiration here was Newton himself, for in an extant draft of Rule Three which, like Keill's version, mentions intention and remission, Newton lists heat, cold, wet, dry, light, dark, colour, blackness, and, most importantly, good and bad odors.[49] For Newton, Rule Three does not apply to these qualities, but Keill, perhaps under the spell of the explanatory power of the inverse square law, saw an opportunity to generalise.

In order to carry out this extension of the Newtonian method, Keill claims, we need to appeal to the observations and experiments of the experimental philosophers. We also need to consult the mechanical philosophers to determine which phenomena can be explained by matter and motion and the laws of mechanics. Keill argues that we cannot start with essences but must start with properties of bodies and that all properties that radiate from a centre in right lines, such as colour, cold, heat, light, can be analysed in the same way as gravity. He then adds two more methodological rules which can be paraphrased as follows:

> Consider only conditions that were supposed at first – the idea is to abstract qualities that are not under consideration, the example is to consider bodies as points without magnitude, shape or colour.

[48] A crucial implicit premise of Keill's natural philosophy is an isomorphism between infinitely divisible space and matter; see Palmerino 2012. Without this, it is impossible to generalise from gravity to the other qualities.

[49] McGuire 1968, p. 237.

> Begin with the most simple cases and then advance to the more complex. e.g., consider bodies in a vacuum or a resistance-free medium.[50]

This is, in fact, a method used by Newton, for example, in his experiments on pendulums.

What are we to make of all of this? And what is its relevance to the fate of experimental philosophy in the early eighteenth century? The first point to keep in mind is that Keill is more than happy to admit that gravity is an occult quality: 'we may call the Endeavour of Bodies to approach one another, Attraction; by which word we do not mean to determine the Cause of that Action . . . And if the true Causes are hid from us, why may we not call them occult Qualities?' (Keill 1720, p. 4). The significance of this will become apparent in Section 4.4. Second, Keill did not remain content with his speculative theory of qualities based on the application of a generalised inverse square law, for in 1708 he published in the *Philosophical Transactions* an article that was an extension of this theory of material qualities. It was, in effect, an attempt to explain material composition, material states, and chemical properties on the basis of the force of attraction and a corpuscular theory of matter. After setting out three principles, namely the existence of vacuums, the infinite divisibility of matter, and the existence of an attractive power in matter, Keill sets out thirty theorems. Our interest commences with Theorem 4. Having noted that Newton had 'in a very beautiful manner' explained the celestial phenomena by the inverse square law, Keill mentions the queries to the Latin edition of Newton's *Opticks* where Newton speculates about attractive forces between particles of matter.[51] Keill then sets out some additional theorems. The first is:

> Theorem 4: Besides that attractive force, by which both planets and comets are retained in their orbits, there is another power in matter, by which all its particles mutually attract, and are mutually attracted. (Keill 1809, p. 419)

He claims that this is established by many experiments, but that it is not clear what power the attraction stands in in relation to distance, that is, it may be triplicate, quadruplicate or some other ratio. Theorem 8 tells us:

> The attractive force, that each particle of matter exerts, in the point of contact, exceeds almost immensely the force of gravity; yet is not infinitely greater than it, and consequently, at a given distance, that attractive force will vanish.[52]

[50] Keill 1720, p. 9.

[51] Keill 1708, p. 99.

[52] Interestingly, Keill's Theorem 8 speaks of this force being superadded to matter. See Keill 1708, p. 101: 'Vis igitur hæc materiæ superaddita'. This is a Lockean doctrine; see Locke 1823, 4, pp. 460–3. For a discussion of a parallel in Newton's discussion of gravity with Leibniz, see Janiak 2015, pp. 128–9.

Keill, by now, has brought a corpuscular matter to bear on his theorems and this speculative theory begins to take over. For example, it provides an explanation of the state of fluidity. He claims in Theorem 10:

> Those corpuscles are most easily separated from each other, which have the fewest and smallest points of contact with other corpuscles; as is the case in spherical corpuscles infinitely small. Hence fluidity is accounted for. (Keill 1809, p. 420)

And before long, Keill is positing additional attractive forces and culminating with a corpuscular account of the properties of salt:

> Theorem 14: The particles of matter, according to their different structure and composition, will be endued with different attractive forces . . .
>
> Theorem 15: The attractive forces of particles perfectly solid, depend very much on their figure.
>
> Theorem 16: Salts are bodies whose particles of the last composition are endued with a great attractive force, though there are several pores interspersed between them, that are pervious to the particles of water of the last composition. (Keill 1809, p. 421)

Thus in 1702 we find John Keill accepting that gravity is an occult quality and defending a speculative theory of material qualities, and all of this inspired, in part, by unpublished revisions to Newton's *Principia* that he says require more experiments. Then in 1708, Keill claims to have performed many more experiments and, inspired now by Newton's speculations in the Queries to the Latin *Optice*, develops an extraordinarily speculative theory of cohesion, bodily states, and chemical composition and reactions which is published in the *Philosophical Transactions*. When Keill's 'Physices *Principia*' is placed alongside John Freind's attempt to develop a Newtonian chemistry in his *Praelectiones chymicae* of 1709, the Continental reaction of incredulity becomes entirely understandable. In a punishing review in the *Acta Eruditorum*, Freind is accused of undoing the great work in chemistry of Boyle and of reintroducing scholastic monsters such as occult qualities. The anonymous reviewer (Christian Wolff) also noted that the precedent for Freind's book is to be found in Keill's article in the *Philosophical Transactions*.[53] The connection between Newton's queries in the Latin *Optice*, Keill's extraordinary speculative theory of attractive forces, and Freind's outrageous chemistry would have been obvious to any careful reader. To cap it all off, John Harris published Newton's own 'De natura acidorum' in the second volume of

[53] Anon. 1710, p. 412. For Wolff's authorship of the review, see Laeven and Laeven-Aretz 2014, p. 66.

his *Lexicon Technicum* in 1710.[54] This manuscript had been in circulation since it was procured from Newton by Archibald Pitcairne in 1692, and it posited attractive forces between particles as an account of acidity.

Newton was fully aware of these developments because he was in the Chair at the Royal Society on 15 November 1711 when Freind read a vindication of the method of his book before the Society. This vindication was subsequently published in Latin in the *Philosophical Transactions* (an English translation appeared in 1712) and represents the first public defence not of Newton's natural philosophy, but of Newton's methodology, in what had now become a very public debate.[55] Freind refers a number of times to Mr L, that is, Leibniz, and addresses the charge that he (Freind) and Newton had reintroduced occult qualities. In particular, Freind defends himself against the charge in the *Acta Eruditorum* review of taking the liberty of feigning (*fingendi licentia*), which would open the door for a return to the occult qualities of the old refuge of ignorance (*ad vetera ignorantia asyla*).[56] Instead, we are to follow Isaac Newton's method:

> The true way certainly of proceeding in these Philosophical Inquiries, is first to find out by many undoubted Experiments, the Properties of Bodies; and then, without any farther Search into the Cause of such Properties, (which perhaps are insearchable) to explain the particular *Phaenomena*, which depend upon them. (Freind 1712, p. 178)[57]

Freind also appeals to John Keill's demonstration in his 'Physiologia', that is, his *Introductio* of 1702, of this other sort of attraction in material bodies over and above gravity (Freind 1711, p. 334). Freind's vindication, therefore, must be seen as setting an important precedent for Newton's methodological comments on feigning hypotheses, occult qualities, and the role of experiment and phenomena in the 'General Scholium' of the second edition of the *Principia*.[58] It is to the *Principia* that we now turn.

[54] Harris 1710, introduction, sigs. b3^{v}–b4^{v}. For the text of 'De natura acidorum', see also *Newton Corr.*, 3, pp. 205–14.

[55] See Freind 1711 and 1712.

[56] Freind 1711, p. 334.

[57] See also Freind 1712, pp. 198: 'it is the business of a true Philosopher, first to discover by Experiments the Properties of Bodies; and then, when they are once certainly establish'd, to shew clearly and distinctly, what Effects naturally flow from them'.

[58] The original source of the references to feigning and occult qualities in this context may well have been Samuel Clarke. For in his notes to his 1710 edition of Rohault's *Traité de physique*, he dismisses sympathies and antipathies as occult qualities in his discussion of gravity and quotes Newton's earlier criticism of feigning (*configere*) hypotheses in Query 20 of the Latin *Optice* of 1706, which had been translated by Clarke himself. See Rohault 1710, pp. 50–1 for occult qualities and feigning and Newton 1706, p. 314 and Newton's 'Principles of Philosophy' in McGuire 1970, p. 185 for feigning hypotheses.

4.4 The *Principia* and Experimental Philosophy

The natural philosophical methodology of the *Principia* had not come in for much critique before 1710 when Nicolaas Hartsoeker in his *Eclaircissemens* criticised Newton's account of gravity for being akin to the introduction of an occult quality: 'To tell the truth, all these suppositions and others by which he attempts to support his ingenious system are worth much less, it seems to me, than the occult qualities of the ancients' (Hartsoeker 1710, p. 29).[59] Soon after its publication, Leibniz wrote to Hartsoeker to discuss some of the doctrines of the latter's *Eclaircissemens*. His letter of 10 February 1711 was fairly critical of Hartsoeker's views. In a broader discussion of *deus ex machina* explanations, Leibniz alluded to Hartsoeker's comment likening Newton's account of gravity to an occult quality:

> the ancients and the moderns, who own that gravity is an *occult quality*, are in the right, if they mean by it that there is a certain mechanism unknown to them, whereby all bodies tend towards the centre of the earth. But if they mean that the thing is performed without any mechanism by a simple *primitive quality*, or by a law of God, who produces that effect without using any intelligible means, it is an unreasonable occult quality.
> (Leibniz 1875–90, 3, p. 519, trans. in Newton 2014, p. 147)

Leibniz here does not mention Newton explicitly (though he does criticise Roberval and Descartes), nor did he introduce the term 'occult'; he was merely picking up Hartsoeker's term. But on the initiative of Bartholomew De Bosses, the letter and Hartsoeker's reply were published in March 1712 in the *Mémoirs de Trévoux* and then in English translation in the *Memoirs of Literature* in the following May.[60] In the latter, they were subtly decontextualised and could easily have been taken as an overt slur on Newton's method.

News of these criticisms reached Roger Cotes on 25 October 1711. William Jones wrote to Cotes 'I have nothing of news to send you; only the Germans and French have in a violent manner attack'd the Philosophy of Sr. Is: Newton, and seem resolv'd to stand by Cartes' (*Newton Corr.*, 5, p. 203). Cotes was initially unconcerned, replying 'I think that Philosophy needs no defence, especially when tis attack't by Cartesians' (*Newton Corr.*, 5, p. 204).[61] By 8 March 1713, however, Cotes was concerned enough consider raising the issue with Newton in relation to the preface that he (Cotes) was preparing for the second edition of the *Principia*, though he lacked the courage. In a passage deleted from a draft letter to Newton, Cotes wrote: 'As for the Preface, I believe

[59] 'Mais à dire la verité, toutes ces suppositions & autres par lesquelles il tâche de soutenir son ingenieux Systeme, valent bien moins, ce me semble, que les qualitez occultes des Anciens.'

[60] See Des Bosses to Leibniz 6 January 1711, Leibniz 2007, p. 190/191; *Mémoirs de Trévoux*, March 1712, Article 40, pp. 494–523; *Memoirs of Literature*, 5 May 1712, pp. 137–43.

[61] Cotes to Jones, 11 November 1711.

it may be of some advantage be very proper that some things should be said in my name which cannot so conveniently be mention'd by Your self. I am not insensible of the little arts which have been used by a certain foreing [*sic*] Mathematician to lessen the credit of Your Book abroad' (*Newton Corr.*, 5, p. 387). He wrote to Richard Bentley two days later: 'As to the Preface, I should be glad to know from Sr Isaac with what view he thinks proper to have it written. You know the Book has been received abroad with some disadvantage, & the cause of it may easily be guess'd at.' Then, after mentioning Leibniz explicitly, Cotes continued:

> I should be very glad if, whilst I am making the Index, he would be pleasd to consider of it [the preface] & put down a few Notes of what he thinks most material to be insisted on. This I say upon Supposition that I write the Preface my self. But I think it will be much more adviseable that You or He or Both of You should write it . . . You may depend upon it that I will own it, & defend it as well as I can, if hereafter there be occasion. (*Newton Corr.*, 5, p. 389)

Clearly, even before it was written, the preface was to be a polemical document aimed at defending Newton's method against the charges of Leibniz.

Bentley replied two days later: 'I communicated your Letter to Sr. Isaac . . . For the Close of your Letter, which proposes a Preface to be drawn up here, and to be fatherd by you, we will impute it to your Modesty; but you must not press it further, but go about it your self' (*Newton Corr.*, 5, p. 390). The letter continues, giving Cotes some guidelines about what the Preface should contain and an assurance that Bentley and Newton will read it, suggesting improvements, and making a recommendation that Leibniz not be mentioned, which would make it seem a 'rude & uncivil' reply. Cotes wrote to Newton about it six days later:

> I have received Dr. Bentley's Letter . . . concerning the Preface. I am very well satisfied with the directions there given, & have accordingly been considering of the matter. I think it will be proper besides the account of the Book & its Improvements to add something more particularly concerning the manner of Philosophizing made use of & wherein it differs from that of De Cartes & others. I mean in first demonstrating the Principles it imploys. (*Newton Corr.*, 5, p. 391)

Then, towards the end of the letter, Cotes finally broached the subject of the foreign criticisms of his method with Newton and how he, Cotes, might counteract them in the Preface:

> I think it will be proper to add some things by which Your Book may be cleared from some prejudices which have been industriously laid against it. As that it deserts Mechanical causes, is built upon Miracles & recurrs to Occult qualitys. That you may not think it unnecessary to answer such

> Objections You may be pleased to consult a Weekly paper call'd *Memoirs of Literature* . . . In the 18th Number of the Second Volume of those Papers, which was published May 5th, 1712 You will find a very extraordinary Letter of Mr. Leibniz to Mr. Hartsoeker which will confirm what I have said. I do not propose to mention Mr. Leibniz's name, t'were better to neglect him; but the Objections I think may very well be answered & even retorted upon the maintainers of Vortices.
>
> (*Newton Corr.*, 5, pp. 392–3)

Newton seems to have procured a copy of the *Memoirs of Literature* soon after taking receipt of Cotes' letter. He penned a knee-jerk reaction to the editor of the weekly, writing 'I wish the author [Leibniz] had behaved himself with more candor & decency towards the English', then crossing it out and opting for a more temperate alternative.[62] (The letter was never published and possibly never sent.) Of course, Leibniz had not mentioned any Englishman at all in his letter; it was Hartsoeker who mentioned Newton in his reply. Nevertheless, in light of the ongoing priority dispute over the invention of calculus and the airing of Leibniz's name in Freind's vindication, Newton saw it as a personal attack.

He had cooled down somewhat by 28 March 1713 when he wrote to Cotes. By this time, he had begun to clarify his thoughts about the best way to respond to Leibniz's criticism – by now Hartsoeker had all but dropped out of the picture – that the appeal to gravity as a property of all material bodies was tantamount to positing an occult quality when instead it should be explained mechanically. The letters of Leibniz, Cotes, and Newton show clearly that this was an issue of natural philosophical methodology or, as Cotes put it, 'the manner of Philosophizing made use of [in the *Principia*]' (*Newton Corr.*, 5, p. 391). Newton then made a very strategic move: he decided to differentiate himself from Leibniz by claiming in the 'General Scholium' that he adhered to the method of experimental philosophy. In his letter to Cotes, he took the opportunity to tidy up a number of issues: he would clarify what he meant by 'hypothesis' – in responding to an earlier draft of the 'General Scholium' Cotes had been concerned that Newton could be accused of feigning hypotheses (*Hypothesim fingere*)[63] – and he would make some additions to the 'General Scholium' that encapsulated his understanding of the method of experimental philosophy in contrast to the method of Leibniz and the Cartesians. To these ends he asked Cotes to add some additional material to the draft:

> At the end of the last Paragraph but two now ready to be printed off I desire you to add after the words [nihil aliud est quam Fatum et Natura.] these words: ' . . . to treat of God from phenomena is certainly part of

[62] Cambridge University MS Add. 3968, fol. 257[r]: http://cudl.lib.cam.ac.uk/view/MS-ADD-03968/519, archived at https://perma.cc/34MV-843E.

[63] Cotes to Newton, *Newton Corr.*, 5, p. 392.

> experimental philosophy'. And for preventing exceptions against the use of the word Hypothesis I desire you to conclude the next Paragraph in this manner 'For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this experimental philosophy, propositions are deduced from the phenomena and are made general by induction. The impenetrability, mobility, and impetus of bodies, and the laws of motion and the law of gravity have been found by this method. And it is enough that gravity really exists and acts according to the laws that we have set forth and is sufficient to explain all the motions of the heavenly bodies and of our sea'.
>
> (Newton to Cotes, 28 March 1713, *Newton Corr.*, 5, p. 397; *Principia*, p. 943)

As Alan Shapiro has claimed, this is unambiguously Newton's response to Leibniz.[64] Where the latter set out the issue as a choice between occult qualities and mechanism, Newton lumps mechanism together with occult qualities as hypotheses and contrasts them with his preferred experimental philosophy. All of this is reinforced by an examination of a draft of this letter, in which Newton reflects more discursively on experimental philosophy and explicitly distinguishes his method from that of Leibniz and Descartes:

> Hypothetical Philosophy consists in imaginary explications of things & imaginary arguments for or against such explications, or against the arguments of Experimental Philosophers founded upon Induction. The first sort of Philosophy is followed by me, the latter too much by Cartes, Leibnitz & some others. (*Newton Corr.*, 5, p. 398–9)

On receipt of the final version of this letter, Cotes found that he now had the polemical stance that he needed for the preface. In a beautifully crafted tactical response, Cotes commences his preface by distinguishing between three classes of natural philosopher. First, there are 'those who have endowed the individual species of things with specific occult qualities, on which – they have then alleged – the operations of individual bodies depend in some unknown way' (*Principia*, p. 385). This is the method of the Aristotelians. Second, there are those who rejecting occult qualities, hold 'that all matter is homogeneous, and that the variety of forms that is discerned in bodies all arises from certain very simple and easily comprehensible attributes of the component particles' (*Principia*, p. 385). However, when they attempt determinate explanations of phenomena, 'even if they then proceed most rigorously according to mechanical laws, [they] are merely putting together a romance, elegant perhaps and charming, but nevertheless a romance'.

[64] A. Shapiro 2004, pp. 200–3. It is also worth considering that Newton may have used this open statement of commitment to experimental philosophy and opposition to occult qualities to distance himself from Keill.

Cotes continues: 'There remains then the third type, namely, those whose natural philosophy is based on experiment. . . . This is that incomparably best way of philosophizing which our most celebrated author thought should be justly embraced in preference to all others' (*Principia*, p. 386). In other words, Newton is an experimental philosopher. With the positions staked out and Newton's method, as briefly described in the 'General Scholium', now affirmed in the preface, Cotes proceeds to discuss universal gravity with a not-too-subtle anti-Leibnizian subtext:[65]

> I know indeed that some men, even of great reputation, unduly influenced by certain prejudices, have found it difficult to accept this new principle [of gravity] and have repeatedly preferred uncertainties to certainties. It is not my intention to carp at their reputation [consistent with what he had told Newton/Bentley], rather, I wish to give you in brief . . . the basis for making a fair judgment of the issue for yourself. (*Principia*, p. 386)

Then after providing an elegant summary of the Newtonian system of the world and reinforcing the fact that experiments are central to establishing universal gravity, Cotes turns again to Leibniz: 'I can hear some people [i.e., Leibniz and Hartsoeker] disagreeing with this conclusion and muttering something or other about occult qualities. . . . Some say that gravity is preternatural and call it a perpetual miracle' (*Principia*, p. 392). This is a poorly veiled allusion to Leibniz's letter in which he writes: 'if anyone should say, it is God's will that a planet should move round in its orbit, without any other cause of its motion, I maintain, that it would be a perpetual miracle' (Newton 2014, p. 146). In the light of the background sketched above, Cotes' target could hardly be more obvious. True to his word, however, he refrains from mentioning Leibniz's name.

Thus, as a result of a polemical exchange and, one must confess, an overreaction on the part of Newton and Cotes, the *Principia* explicitly became a work of experimental philosophy. There was nothing forced about this. As we have seen, Newton's early optical writings were entirely consistent with the experimental philosophy of the early Royal Society and, moreover, as Shapiro has pointed out, Newton used the term 'experimental philosophy', unpolemically, in a draft version of Query 23 to the 1706 Latin edition of the *Opticks*.[66] Experimental philosophy was already established in Newton's intellectual milieu in the years leading up to the publication of the second edition of the *Principia* and being endorsed by those around him, such as John Freind, who in his *Praelectiones chymicae* affirmed Boyle as 'that remarkable restorer of experimental philosophy'.[67] Furthermore, given his long-standing, deep

[65] A fact not lost on Leibniz, who described it as *pleine d'aigreur* (full of bitterness); Leibniz to Conti, 9 April 1716, *Newton Corr.*, 6, p. 304. See also Leibniz to J. Bernoulli, 27 May 1761, *Newton Corr.*, 6, p. 354.

[66] A. Shapiro 2004, p. 189.

[67] Freind 1709, 2: 'insignis ille Philosophiae experimentalis instaurator Boyleus'.

reservations concerning the use of hypotheses, Newton had carefully reworked the list of nine hypotheses at the beginning of Book Three of the first edition, changing the first two into Rules of Philosophising, deleting the third and replacing it with a third rule that emphasises experiment, and renaming all but one of the remaining hypotheses as phenomena.[68]

However, once Newton became explicit about his method of philosophising, there was no turning back: the *Principia*, the most important work of natural philosophy in the period, had unambiguously become a work of experimental philosophy. And it remained so: when Newton added a fourth rule for philosophising to the third edition in 1726, it was a rule about experimental philosophy: 'In experimental philosophy, propositions gathered from phenomena by induction should be considered either exactly or very nearly true notwithstanding any contrary hypotheses, until yet other phenomena make such propositions either more exact or liable to exceptions.' (*Principia*, p. 796)[69] We believe that it can be argued that Newton openly aligned himself with experimental philosophy in the exchange over the status of gravity because of the credibility that this approach to natural philosophy already possessed. This is not to say that Newton had not already privately identified with the method and the movement; this is not to say that the status of experimental philosophy did not benefit enormously from his open advocacy of it after the second edition of the *Principia* appeared in 1713. But it is to say that the epistemic status and social credibility of experimental philosophy, epitomised by experimental pedagogy, provided a broad-based, well-established methodological and practical foundation from which to launch his attack on his Continental detractors.

Our story does not end here, however, for the anti-Leibnizian polemics continued and spilled over into the ongoing priority dispute over the invention of calculus. In 'An Account of the Book Entitled *Commericum Epistolicum*' of 1715, Newton, under the cloak of anonymity, attacks Leibniz's letter to Hartsoeker point by point. What is extraordinary about all of this is that Leibniz is not criticising Newton but Hartsoeker. It was Hartsoeker who explicitly criticised Newton, but Newton seems to have read Leibniz's letter as if it were largely directed against him. First, Newton demarcates using the ESD and picking up material that appeared earlier in his draft letter to Cotes: 'these two Gentlemen differ very much in Philosophy. The one proceeds upon the Evidence arising from Experiments and Phaenomena, and stops where such Evidence is wanting; the other is taken up with Hypotheses, and propounds them, not to be examined by Experiments, but to be believed without

[68] See the table on p. 794 of the *Principia*. For detailed discussion, see Cohen 1966.

[69] There are strong grounds for claiming that Rule 4 was derived, at least in part, from Newton's draft letter to Cotes of 28 March 1713. Among the parallels in the letter is Newton's comment on 'Hypotheses in opposition to rational Propositions founded upon Phaenomena by Induction', *Newton Corr.*, 5, p. 398.

Examination' (Newton 1715, p. 224). Newton then turns to gravity. Where Leibniz had claimed to posit 'that all bodies attract one another by a law of nature' is to posit a perpetual miracle, Newton responds 'The one [Newton] for want of Experiments to decide the Question, doth not affirm whether the Cause of Gravity be Mechanical or not Mechanical: the other [Leibniz] that it is a perpetual miracle if it be not Mechanical' (Newton 1715, p. 224).

Next, Newton raises hardness. Where Leibniz had claimed 'The same ought to be said of hardness. . . . if he pretends that hardness proceeds from any other cause than mechanism . . . he recurs to a quality that is so occult, that it can never be made clear' (Newton 2014, p. 147), Newton responds 'The one [Newton] (by way of Enquiry) attributes it to the Power of the Creator that the least Particles of Matter are hard: the other [Leibniz] attributes the Hardness of Matter to Conspiring Motions' (Newton 1715, p. 224).[70]

Next comes mind–body interaction. Leibniz claimed that how a substance comes to have life and perception 'is more intelligible in my system of the pre-established harmony, by conceiving that our spiritual substances do naturally represent what happens in that part of matter to which they are united'. Newton responds 'The one doth not affirm that animal Motion in Man is purely mechanical: the other teaches that it is purely mechanical, the Soul or Mind (according to the Hypothesis of an *Harmonia Praestabilita*) never acting upon the Body so as to alter or influence its Motions' (Newton 1715, p. 224).

For Leibniz, God is *intelligentia supramundana* and the cause of the world. For Newton:

> The one teaches that God . . . is Omnipresent; but not as a Soul of the World: the other [Leibniz] that he is not the Soul of the World, but INTELLIGENTIA SUPRAMUNDANA, an Intelligence above the Bounds of the World; whence it seems to follow that he cannot do any thing within the Bounds of the World, unless by an incredible Miracle.
>
> (Newton 1715, p. 224)

Newton here is turning Leibniz's own weapon against him: it is Leibniz who must resort to miracles. We could go on ticking off Newton's points against Leibniz in this work, but the main point for us to glean here is the role of experimental philosophy in the polemics. The dispute continued, revolving around these very same issues, until Leibniz's death.[71] Interestingly, however, on the question of experimental philosophy Leibniz claimed that he saw eye-to-eye with Newton. He wrote to Antonio Schinella Conti on 25 November 1715:

> I strongly approve of his method of drawing from phenomena what can be drawn without making any suppositions, even if sometimes this is only

[70] For Leibniz's doctrine of conspiring motions, see Anstey 2016.

[71] See, for example, Leibniz to Conti, November 1715 and 9 April 1716 for the *intelligentia supramundana*, pre-established harmony, and so on, in Alexander 1956, pp. 184–8.

> drawing conjectural consequences. However, when the *data* are not sufficient, it is permissible ... to imagine hypotheses, and if they are good ones to hold them provisionally, waiting for new experiments to bring us *nova data* and for what Bacon calls *experimenta crucis*, in order to choose between hypotheses. ... I am strongly in favour of experimental philosophy. (Alexander 1956, p. 186; *Newton Corr.*, 6, p. 252)

Leibniz's reference here to Bacon's crucial experiments reminds us that the great Lord Chancellor continued to be regarded as having made a seminal contribution to experimental philosophy. However, in none of the contributions to this polemical exchange do we find references to Baconian natural history. Indeed, there is strong evidence for the claim that in the last years of his life, Newton was strongly opposed to natural history having a central role in natural philosophical methodology.

4.5 Newton and Natural History

Peter Shaw, in his new edition of Boyle's works of 1725, prefaced the third volume, the volume on natural history, with the following words: 'Natural history seems at present to lie under some disgrace, upon account of the small benefit that is presumed to arise from the study of it' (Boyle 1725, 3, p. 3).[72] How the discipline of natural philosophy had changed! Recall how Henry Oldenburg described the aims of the Royal Society sixty years earlier: 'It being the Design of the R[oyal] Society, for the better attaining the End of their Institution, to study *Nature* rather than *Books*, and from the Observations, made of the *Phaenomena* and Effects she presents, to compose such a History of Her, as may hereafter serve to build a Solid and Useful Philosophy upon' (*Philosophical Transactions*, 1.8, 1665, pp. 140–1). Just two years after Shaw's comment, in 1727, in the thirty-fourth volume of the *Philosophical Transactions*, James Jurin, then the outgoing Secretary of the Royal Society, summed up the views of many within the Society in an open letter to the Vice-President Martin Folkes:

> That Great Man [Isaac Newton] was sensible, that something more than knowing the Name, the Shape and obvious Qualities of an Insect, a Pebble, a Plant, or a Shell, was requisite to form a Philosopher, even of the lowest rank, much more to qualifie one to sit at the Head of so great and learned a Body. We all of us remember that Saying so frequently in his Mouth, That *Natural History might indeed furnish Materials for Natural Philosophy; but, however, Natural History was not Natural Philosophy*; and it was easy for all his Friends to see, with what intent he so often us'd

[72] Richard Steele had mocked the lack of utility of natural history back in 1711 in *The Spectator* of 24 March. See Steele and Addison 1888 [1711–12], p. 37, quoted in Anstey 2005, p. 237.

> this remarkable Expression. We knew his Love to the *Royal Society*, and his Fears for it. It was not that he despis'd so useful a Branch of Learning as *Natural History*; he was too wise to do so: But still he judg'd that this humble Handmaid to Philosophy, tho' she might be well employ'd in amassing Implements and Materials for the Service of her Mistress, yet must very much forget her self, and the Meanness of her Station, if ever she should presume to claim the Throne, and arrogate to her self the Title of the *Queen of Sciences*. (Jurin 1728, sig. A2^{r-v})

Jurin's comments here echo those of Peter Shaw that natural history lies 'under some disgrace' because of the few benefits that it has given rise to. These two comments might be taken as encapsulating the broad shift for which we have been arguing – from experimental natural philosophy being practised according to the method of Baconian natural history to a form of mathematical experimental natural philosophy that took as its prime exemplar the work of Sir Isaac Newton. However, it is important to stress that this development was in no way a clear-cut methodological switch, but a gradual transition that occurred over three decades and which reflects some degree of methodological confusion and ambiguity. This can be illustrated by Newton's own engagement with natural history and the views and practices of those within his ambit.

As we saw in Section 4.1, Newton's early exposure to the Baconian method of natural history is reflected in his early optical writings. Newton's use of experiments in his first paper of 1672, his use of queries, his reservations about hypotheses, and his emphasis on the primacy of observation and experiment all sit well with the Baconian approach that was being fostered in the early Royal Society. It is of singular interest, therefore, that at the very same time that Newton was composing his first optical paper he was engaged in another natural philosophical project that had deep connections with Baconian natural history. This was his 1672 edition of Varenius' *Geographia generalis*.

In Chapter 3, we argued that from the 1650s in Britain, geography was subsumed under the broader Baconian rubric. This is epitomised in the fact that Boyle's 'General heads for a natural history of a countrey' has a close correspondence with Varenius' heads for the special geography of a location. Newton was clearly apprised of Boyle's 'General heads' because he mentions them in his notes on the first twenty-four issues of the *Philosophical Transactions*, describing them as 'Boyls directions for the generall History of a country' (Cambridge University Library, MS Add. 3958, fol. 11^{r}). Newton made these notes around 1667. As for Varenius, Newton would already have encountered references to the *Geographia* when reading Boyle's *Spring of the Air* in the mid-1660s.[73] It is also likely that he learnt about Varenius' book from Barrow, because the statutes of the Lucasian chair at Cambridge require the incumbent to instruct and lecture in geography. In fact, the editors of the first

[73] *Spring of the Air*, B 1 214, 248, 286.

eighteenth-century English translation of Varenius' work claimed that Newton corrected and published his own edition of Varenius 'because he thought him [Varenius] necessary to be read by his Audience . . . while he was delivering Lectures upon the same *Subject* from the *Lucasian Chair*'.[74] The truth of this claim has not yet been independently verified, however.

Of course, the mathematical parts of geography would have appealed to Newton. Indeed, in his optical lectures from this period he mentions geography as akin to optics in this respect:

> the generation of colors includes so much geometry, and the understanding of colors is supported by so much evidence, that for their sake I can thus attempt to extend the bounds of mathematics somewhat, just as astronomy, geography, navigation,[75] optics, and mechanics are truly considered mathematical sciences even if they deal with physical things.
>
> (Newton 1984, p, 87)

And it was in the mathematical details of the *Geographia generalis* that Newton made his most important contributions, correcting numerous computational errors and introducing new diagrams and tables.[76] In addition, Newton made many improvements to the text. Warntz, who has analysed Newton's corrections and additions in detail, claims: 'on virtually every page, grammatical and typographical errors were corrected. Some awkward portions of the text were rewritten and qualifying phrases added.'[77]

We conclude, therefore, that Newton's contribution to geography in his many corrections and additions to Varenius' *Geographia generalis* are best seen as his making a mathematical contribution to a major source of cosmographical and geographical facts, a source that continued to be plundered by those writing experimental natural histories, such as Plot's *The Natural History of Stafford-Shire* which cites the *Geographia* extensively.[78] Whether Newton himself saw this as a contribution to Baconian natural history in 1672, or in the revised edition of 1681, is a moot point. What is important is the manner in which his own contributions to geography and optics were grafted into the broader fabric of British experimental philosophy at the time.

Furthermore, whether or not Newton regarded his work in optics as a contribution to natural history, there is good evidence that it was so regarded by others within his ambit. Samuel Clarke, for example, having just prepared

[74] Warntz 1989, p. 177.
[75] It is worth pointing out that the final six chapters of Varenius' *Geographia generalis* concern navigation.
[76] Newton changed the prose list of heads for special geography, discussed in Chapter 3 above, to tabular form. Compare Varenius 1650, pp. 3–4 with Varenius 1672, p. 8.
[77] Warntz 1989, pp. 179–81.
[78] See Plot 1686, pp. 52–3, 59, 65, 70, 71, 91, 104.

a Latin translation of the *Opticks*, wrote to Roger North concerning Newton's methodological views on 28 September 1706:

> Hence you see why Sir Isaac makes no *system of physicks*. He will never make any *hypothesis*; and though he has many more things *lying behind*, yet he will bring nothing forth, till it be arrived either to the certainty of *natural history*, or *geometrical demonstration*. The book of light and colours is an example in one instance, how mere *natural history* without any *hypothesis* at all, is the only way to true philosophy.
>
> (Kassler 2014, p. 146)

This very telling extract, from a letter replete with the rhetoric of experimental philosophy, could not be more explicit about the *Opticks* as a work of natural history. Clarke even intimates that it is Newton's view that 'it would be a sufficient perfection of natural philosophy, if we could thus compleat *natural history*' (Kassler 2014, p. 146).[79] Clearly, in 1706 Clarke felt no antipathy to the discipline.

Interestingly, the Royal Society's *Journal Book* from this period reveals that Newton himself had made what can only be called natural historical observations at the Society's meetings. Entries for 21 June and 22 November 1704 are as follows:

> The President [Newton] said that he had taken a small Animal out of a wet Ditch, & cut it into 3 pieces, all which continued to move in water, for 3 days & nights.
>
> The President [Newton] Related that Moistened Bran would continue hott, for a fortnight or 3 weeks, by putting now & then some additional Moisture to it.[80]

Even in the clutch of publications arising from the Newtonian attractionists discussed earlier, we find references to the importance of natural history to natural philosophy. For example, the physician James Keill, the younger brother of John Keill, wrote an attractionist work, *An Account of Animal Secretion*, about the secretion of animal fluids and muscular action, based on his brother's speculative theory of attractive forces between particles: 'This Power, by which the Particles of the Blood attract one another, is the same with that which is the Cause of the Cohesion of the Parts of Matter: And was first communicated to me by my Brother at *Oxford*' (James Keill 1708, p. 7). This book was of a piece with Freind's *Praelectiones chymicae*, even referring to the queries to Newton's Latin *Optice* for authority,[81] and in its methodological

[79] Clarke to North, 28 September 1706. For his part, North claims of Newton's *Opticks*: 'under the discuise of declining all hypotheses, & professing onely Naturall history yet he Sets up an hipothesis upon principles, of which Nothing is seen, felt, or understood', British Library Add. MS 32545, fol. 271^{r}.

[80] Royal Society Journal Book, vol. x1, pp. 53 and 58.

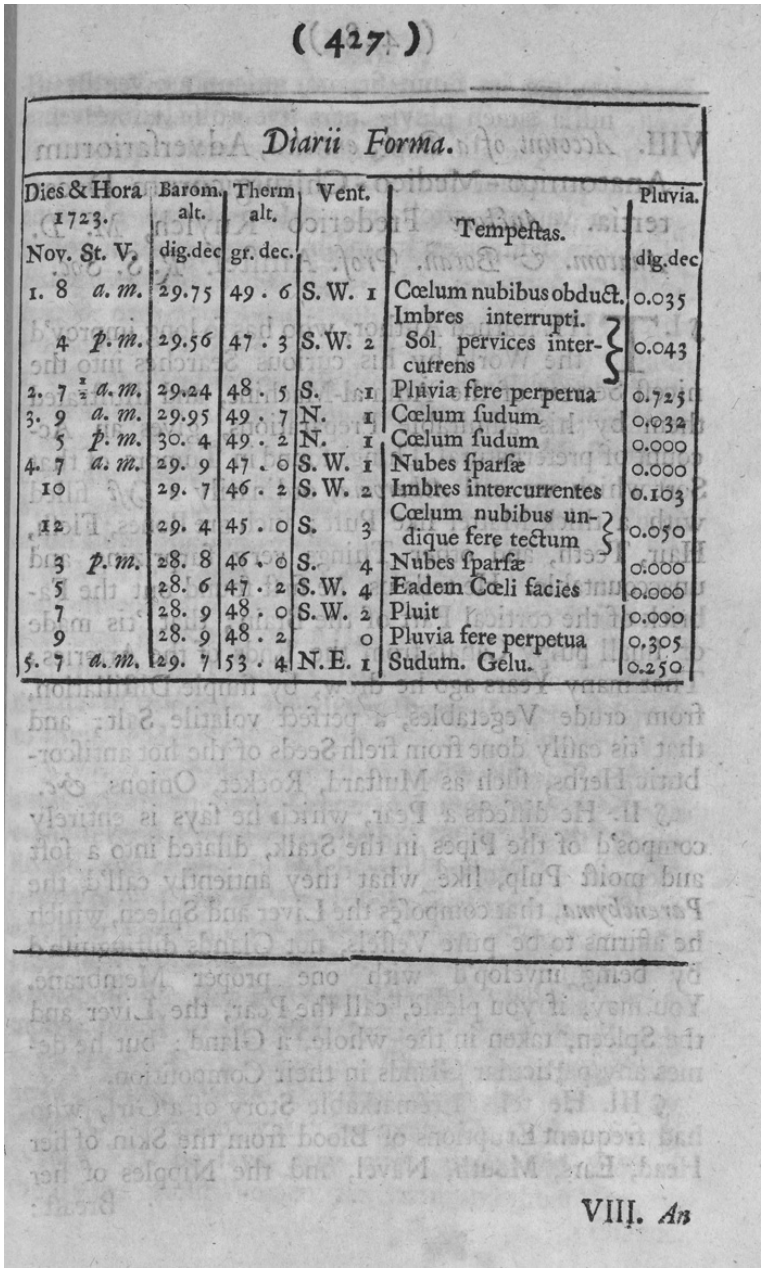
[81] James Keill 1708, pp. 8–9.

preface, the younger Keill is at pains to stress the importance of natural history to physic: 'Natural Phylosophy and the Histories of Diseases must go hand in hand in the improving the Art of curing; it is not possible to make any use of the last without the Knowledge of the first' (James Keill 1708, p. xxiii). Thus, it would be wrong to regard the – albeit short-lived – fad for attractionism as reflecting a purely mathematical approach to natural philosophy.

However, the most important evidence to show that the transition from natural history to mathematics in early eighteenth-century experimental philosophy was a gradual transition is found in the works of James Jurin. At the urging of Richard Bentley, Jurin prepared yet another edition of Varenius' *Geographia generalis*, which appeared in 1712. It may be that Jurin regarded this as a contribution to the broader project of experimental natural history, particularly in the light of his later contributions to the natural history of the air. However, the most significant feature of this third Cambridge edition was the manner in which the Cartesian cosmological theses and diagram had been excised and replaced with Newtonian theory. Where the original and Newton's first two editions contained much Cartesian content, including a diagram illustrating the Cartesian vortex theory copied directly from Descartes,[82] Jurin's edition contained no such diagrams and had a new appendix arguing against the vortex theory. As Warntz has argued, the timing of the appearance of this edition could not have been more appropriate, coming out as the second edition of the *Principia* was in the final stages of production with its ramped-up anti-Cartesian polemics. Thus, Jurin stood to 'Newton's Varenius' as Cotes stood to Newton's *Principia*, and these works, together with Newton's *Optice*, ably translated by Samuel Clarke, represented a wide-ranging, experimentally-based mathematical natural philosophy.

We turn now to Jurin's more specific contributions to natural history. That Jurin had contributed some 'Remarks on a fragment of an old Roman inscription found in the North of England' to the *Philosophical Transactions* in 1719, might seem of little consequence. However, we would argue that the reason the *Transactions* had long been a forum for the publication of articles on antiquities was because these were thought to form part of the natural histories of countries and counties. Jurin's short piece is best regarded as a contribution to a natural history. What is of greater interest, however, is his call in 1723 for meteorological observations so as to assemble a natural history of the air. Jurin's request is for data acquired and arranged in a manner that closely parallels the weather charts of John Locke and others that derived from Boyle's earlier conception of a general history of the air (see Figure 4.3). Indeed, like Boyle and Locke, Jurin includes the effects of weather on human health as one of the motivating reasons for this call 'to cultivate this part of natural history' [*ad excolendam hanc partem Historiae Naturalis*], what he describes as

[82] See Descartes 1644, p. 222 and Varenius 1681, figure 15.



(427)

Diarii Forma.

Dies & Hora 1723. Nov. St. V.		Barom. alt. dig.dec	Therm alt. gr. dec.	Vent.		Tempeſtas.	Pluvia. dig.dec
1. 8	*a. m.*	29.75	49 . 6	S. W.	1	Cœlum nubibus obduct.	0.035
						Imbres interrupti.	
4	*p. m.*	29.56	47 . 3	S. W.	2	Sol pervices intercurrens	0.043
2. 7	½ *a. m.*	29.24	48 . 5	S.	1	Pluvia fere perpetua	0.725
3. 9	*a. m.*	29.95	49 . 7	N.	1	Cœlum ſudum	0.032
5	*p. m.*	30. 4	49 . 2	N.	1	Cœlum ſudum	0.000
4. 7	*a. m.*	29. 9	47 . 6	S. W.	1	Nubes ſparſæ	0.000
10		29. 7	46 . 2	S. W.	2	Imbres intercurrentes	0.103
12		29. 4	45 . 0	S.	3	Cœlum nubibus undique fere tectum	0.050
3	*p. m.*	28. 8	46 . 6	S.	4	Nubes ſparſæ	0.000
5		28. 6	47 . 2	S. W.	4	Eadem Cœli facies	0.000
7		28. 9	48 . 0	S. W.	2	Pluit	0.000
9		28. 9	48 . 2		0	Pluvia fere perpetua	0.305
5. 7	*a. m.*	29. 7	53 . 4	N. E.	1	Sudum. Gelu.	0.250

VIII. *An*

Figure 4.3 James Jurin's weather diary exemplar, *Philosophical Transactions*, 32.379, 1723, p. 427. Used with permission. Image supplied by the National Library of Scotland

a 'history of the air' [Aeris Historiam] (Jurin 1723, p. 423). Thus, when Jurin found cause to recall Newton's strictures against natural history after the latter's death, it should not be inferred that Jurin himself was an outright opponent of natural history. How then should we interpret Newton's remark and Jurin's pointed use of it in his parting issue of the *Philosophical Transactions*?

If we focus on the distinction between Baconian natural history – the architectonic project that encompassed the whole of the study of nature – and classificatory natural history, Newton's complaint is ostensibly against the latter. After all, he claims that 'something more than knowing the Name, the Shape and obvious Qualities of an Insect, a Pebble . . . was requisite to form a Philosopher'. However, Newton's refrain that natural history is not natural philosophy resonates with the former, that is, with the Baconian conception that regarded natural history as all but constitutive of natural philosophy. What is evident if we take Newton's comments, as reported by Jurin, is that this (entirely understandable) conflation on Newton's part of classificatory natural history with Baconian natural history ultimately reflects the failure of the promoters of the Baconian programme of experimental natural history to differentiate their project from traditional classificatory and descriptive natural history. What Jurin was aiming for in his appeal for meteorological observations was a legitimate *experimental* history of the air. What Newton was criticising was the over-valuing of *classificatory* natural history. Yet, in the absence of a clearly articulated theoretical substructure by which to differentiate the two enterprises, it was easy then, as it is now, to regard them as constituting the same enterprise. Jurin's comments then are, perhaps, best interpreted as a note of caution to the Society in the light of the appointment as the new President of Sir Hans Sloane, who lacked the mathematical orientation of his predecessor and was feared likely to take the Society in a new direction.[83]

4.5 Conclusion

This chapter has addressed the complicated, even convoluted, process by which a mathematical form of experimental natural philosophy in England replaced the natural historically oriented form of experimental philosophy that had been promoted in the decades following the foundation of the Royal Society in 1660. By the late 1720s, natural history was under 'some disgrace', and the Newtonian approach was strongly in favour. Newton's open advocacy of experimental philosophy in his polemics against his Continental antagonists, combined with the proliferation of courses and textbooks on experimental philosophy, represent a kind of heyday for the movement in Britain. To be sure, this new way of doing natural philosophy had its critics, but in Britain at

[83] For a different interpretation of the motivation of Jurin's comments, see Feingold 2001.

least it faced no serious competitor. As its importance grew in the second decade of the new century, the flame spread to the Dutch Republic as a result of the successive visits to England of Willem 's Gravesande and Pieter van Musschenbroek. By the third decade, it came under the close scrutiny of Voltaire during his sojourn in England. The process by which experimental philosophy spread to France is the subject of the next chapter.

CHAPTER 5

Experimental Philosophy in France

We have argued that in the latter decades of the seventeenth century, experimental philosophy was primarily practised according to the method of Baconian or experimental natural history. Further, we claimed that in the 1690s a new form of experimental natural philosophy emerged in Britain. This was the mathematical form of experimental philosophy that was exemplified in Newton's magisterial *Principia* and which begins to emerge in the pedagogical writings and lectures of the likes of William Whiston and John Theophilus Desaguliers. It was taken up in the Netherlands in the apologetical writings of Lambert Ten Kate and Bernard Nieuwentijt, and then by Willem 's Gravesande in his very popular *Physices elementa mathematica* (1720–1). In this chapter, we examine the impact of experimental philosophy in France from the mid-1730s through to the period in which the *philosophes* were at the forefront of French intellectual life, the period normally called the French Enlightenment. First, however, we need to cast our minds back to the seventeenth century and to examine the uptake in France of Francis Bacon's vision for a great instauration of natural philosophy. For while experimental philosophy was only seriously and overtly embraced from the mid-1730s in France, some of the core ideas that characterised experimental philosophy in England were manifested in France in the previous century. To that end, we first examine the early French response to Francis Bacon and his conception of natural history.

5.1 Bacon and the Early Académie des Sciences

The development of French natural philosophy and the place of natural history within it during the first half of the eighteenth century is a fascinating but complex subject. It is intimately tied, on the one hand, to the establishment of the regional academies and their interplay with Paris[1] and, on the other hand, to the French reception and appropriation of developments in Britain and the Netherlands, including the reception of Newtonianism and experimental

[1] For a survey, see Roche 1996.

philosophy. There is a discernible Baconian thread in a number of phases of this story; at times, it is rather tenuous, and at other times, it is more robust.

As we saw in Chapter 3, the story begins before the establishment of the Académie Royale des Sciences with a 'Project de la Compagnie des Sciences et des Arts' of Christiaan Huygens datable to around 1663. This document bears many parallels with similar recommendations that were formulated across the Channel for the Royal Society of London and may well have been influenced by the views of Sir Robert Moray, with whom Huygens was corresponding at the time. Huygens later suggested to Colbert that the activities of the new academy ought to be conceived in terms of what can only be described as Baconian natural history 'following the design of Verulam'.[2]

From the late 1660s, we find a steady trickle of French translations of English works promoting Baconian natural history, such as Thomas Sprat's *L'Histoire de la Societe Royale de Londres* (1669), or of exemplars of this genre, such as Joshua Childrey's *Britannia Baconica*, translated as *Histoire Des Singularitez Naturelles D'Angleterre, D'Ecosse, et Du Pays De Galles* (1667). This continued into the 1670s with translations of Boyle on tastes and odours and two translations of Grew's experiments on luctation.[3] Guy Mesmin, one of Grew's translators, speaks of his experiments in consort as 'the best method I can imagin, by which one may enter into the knowledge of bodies' (*Boyle Corr.*, 5, p. 140). We also find a flourishing group of natural philosophers practising and publishing natural history.[4] It is hardly surprising then to find that some facets of the Baconian conception were prominent among the French natural philosophers who worked in natural history. The first is a very clear distinction between the historical and theoretical parts of natural philosophy. This is nicely illustrated in the Preface to the first volume of Claude Perrault's *Essais de physique* (1680), 'For natural philosophy having two parts, knowing the philosophical and the historical' (Perrault 1680, 1, sigs. aij^{r-v}).

The second prominent Baconian conception, following on from the first, is the two-stage view of the method of natural philosophy. Interestingly, this Baconian notion that the Académie was to establish a factual foundation as a propaedeutic to theorising still features as a constituent of the methodology of the Académie at the end of the century as we see in the words of Fontenelle, who in the *Histoire de l'Académie Royale des Sciences* of 1699 wrote 'the Academy is only at the stage of gathering an ample store of well-founded observations and facts, which will one day become the basis for a System. For systematic natural philosophy it must refrain from building its edifice until experimental natural philosophy is able to furnish it with the necessary

[2] Huygens 1888–1950, 6, pp. 95–6; see also Huygens 1888–1950, 19, p. 268.
[3] Boyle 1679; Grew 1679a, 1679b.
[4] Perrault 1671–6; Dodart 1676; Stroup 1990.

materials' (Fontenelle 1708, sig. Ciij^{r-v}).[5] There is no reference to the role of natural history in Fontenelle's discussion, but the rhetoric of the new experimental philosophy is clear enough.

The same volume contains Fontenelle's *éloge* for his predecessor as Secretary to the Parisian Academy, Jean-Baptise du Hamel, in which he describes du Hamel's visit to London in 1669 in the following way: 'he made this trip as a philosopher, his principal curiosity was to see the virtuosi, above all the illustrious Mr Boyle who opened to him all the treasures of experimental philosophy [*Phisique Experimentale*]' (Fontenelle 1708, p. 203). In fact, du Hamel is the member of the Parisian Academy who gave experimental philosophy its most enthusiastic reception. He had been encouraged by Jean Chapelain to 'have as many contacts as possible with M. Boyle and the other leading English scientists' (Sturdy 1995, p. 148) while he was in London, and it seems that he followed this advice. For on his return to Paris, he kept in touch with Oldenburg and began writing on natural philosophy in a manner that reveals he had imbibed the 'experimental ethos' of the Royal Society across the Channel.

Between 1670 and 1673, du Hamel wrote three Latin works that show the impact of British experimental philosophy on this thought; each one has the word *experimenta* in its title. In particular, he had become an avid reader of Boyle and incorporated numerous references to Boyle's experiments and writings in these books. The first, *De corporum affectionibus ... seu promotae per experimenta philosophiae specimen* (On the affections of bodies ... or a specimen of philosophy exhibited by experiments) was dedicated to Colbert and incorporated material from Boyle's *Forms and Qualities*.

The second, *De mente humana ... variis illustrata experimentis pertractantur* (On the human mind ... in which the functions of the mind being elucidated are investigated by various experiments) sets out an account of human understanding that includes a logic and a treatment of Baconian induction in natural philosophy that makes extensive reference to experiments and claims that experiments are essential for acquiring knowledge of natural things. Du Hamel later calls induction 'the principal instrument of experimental philosophy [praecipuum est experimentalis Philosophiae organum]' (Du Hamel 1673, sig. bi^{r}). *De mente humana* shows a clear appreciation of the ESD, mentions Baconian natural history, and alludes to a number of Boyle's experiments and observations from works such as *Usefulness of Experimental Natural Philosophy*.[6] The book is, perhaps, the French publication that comes closest to Locke's *Essay* before the appearance of Condillac's *Essay on the Origin of Human Knowledge* in 1746.

[5] Citing Hahn's translation with modifications. See Hahn 1971, p. 33.
[6] See, for example, du Hamel 1672, pp. 413–14.

The third book in du Hamel's trilogy, the *De corpore animato . . . seu promotae per experimenta philosophiae specimen alterum* (On the living body . . . or another specimen of philosophy brought to light by experiments), continues the deployment of experiments, though now applied to sense perception. At one point, du Hamel refers to Boyle's *Flame and Air* which had just been printed, adding that his copy had just been sent to him by Boyle himself.[7] Yet for all this, the fact remains that the structure and contents of these works are very scholastic. *De corpore animato*, for example, is structured around the scholastic distinction between internal and external senses. Again, the logic – except for the digression on induction – and the metaphysics of *De mente humana* are strongly Aristotelian. It is hardly surprising, therefore, to find Tad Schmaltz concluding that in his popular textbook *Philosophia vetus et nova* (1678), du Hamel's discussion of Cartesian mechanical philosophy shows how it can be 'absorbed into the Aristotelian system' (Schmaltz 2016, p. 114). Furthermore, when du Hamel does refer to experiments, they are invariably used for illustrative purposes rather than as heuristic guides for acquiring new knowledge of nature. It is, therefore, difficult to classify du Hamel as an experimental philosopher *stricto sensu*.

In the light of du Hamel's long-standing enthusiasm for experimental philosophy, it is important to note that there was a prominent philosopher who was a critic of experimental philosophy in France as early as 1674. This was Nicolas Malebranche, who in his *Search after Truth* lists seven defects of experimental philosophers, adding that there are 'still many other defects, but we do not pretend to cover them here' (Malebranche 1674, p. 354 = 1997, p. 160). It is somewhat ironic that Malebranche's section on experimental philosophers appears to take its inspiration from Aphorism 65 of Book One of Bacon's *Novum organum*, which Malebranche cites in the previous section. In that aphorism, Bacon criticises the '*Empirical* family of philosophy', namely, the chemists and 'those who daily deal with experiments' (OFB 11 101). Malebranche follows suit but gives a longer list of criticisms: first, their order of experiments is determined by chance, not reason; second, they are preoccupied with unusual experiments; third, they seek profitable experiments and neglect those that enlighten the mind; fourth, their experiments are performed without sufficient care; fifth, they draw too many conclusions from a single experiment; sixth, they 'consider only particular effects', never ascending to primary notions; and seventh, 'they lack courage and endurance, and give up because of fatigue and expense' (Malebranche 1674, pp. 246–8 = 1997, pp. 159–60). He asks the reader not to blame experimental philosophy ('On ne blâme donc point la philosophie experimentale'), though his diagnosis of the causes of these defects reveals that he is opposed to experimental philosophy in principle.

[7] Du Hamel 1673, p. 497: 'Hunc ad me cum ista scriberem, pro sua humanitate misit.' *Flame and Air* was not available until March 1673; see B 7 xxi.

5.2 The Heyday of Experimental Philosophy in France

The situation with regard to the uptake of experimental philosophy in France is, however, markedly different from its manifestation in Britain.[8] It is true that the early Académie openly endorsed the importance of experiment in natural philosophy.[9] Indeed, from the turn of the century there was great interest in public experimental demonstrations.[10] It is also true that one can find instances of the sort of anti-speculative and anti-hypothetical rhetoric so prevalent amongst British experimental philosophers in writers such as Fontenelle. Nevertheless, it appears that the adoption of experimental philosophy as a distinctive natural philosophical method and an open identification with the movement did not occur in France until the 1730s. This is not to claim that it appeared *de novo* at that time. Thus, for example, a gradual awakening to the explanatory potential of experimental philosophy is evident in differences between the first two editions of Pierre Polinière's *Expériences de physique* of 1709 and 1718. Polinière was a successful demonstrator of natural philosophical experiments who operated in Paris from the late 1690s. In the first edition of his book, the rationale of experiment was to 'confirm' natural philosophical principles 'and make their truth better understood' (Polinière 1709, Preface, p. v; R. W. Home 1985, p. 116). By the second, 1718 edition, however, Polinière could confidently assert that experimental philosophy was held in 'great esteem' and that experiment provided 'the shortest and most sure way to a knowledge of the essence and properties of bodies' and the 'immutable laws of nature' (Polinière 1718, sig. viii). And yet, just a year later, some of Polinière's experiments were incorporated into Jean Denyse's *La nature expliquée par le raisonnement et par l'expérience* in such a way as to show that they merely serve to confirm his natural philosophical theory. This is a clear indication that experimental philosophy was yet to be embraced in the Collège de Montaigu of the University of Paris where he taught.[11]

All this changed in the mid-1730s, when a series of factors coalesced to bring experimental philosophy to the fore. These include first Voltaire's endorsement of experimental philosophy in his letter on Bacon in the *Lettres philosophiques* of 1734, and his promotion and popularisation of Newtonianism.[12] Voltaire regarded Bacon as the originator of experimental philosophy: 'in a word, no one, before the Lord *Bacon*, was acquainted with experimental

[8] The best short study of the uptake of experimental philosophy in France remains Torlais 1964. See also Pépin 2012.

[9] For a detailed study, see Salomon-Bayat 1978, première partie, pp. 29–105.

[10] For a description of Guillaume Dagoumer's popular public experimental demonstrations, see *Mercure Galant*, August 1701, pp. 281–6, cited in Shank 2008, p. 155. For a general treatment of the nature of public science in eighteenth-century France, see Lynn 2006.

[11] See Denyse 1719, pp. 311–13, 379–85, 425–31.

[12] Voltaire 1734, pp. 89–101. See also Shank 2008, pp. 309–11.

Philosophy' (Voltaire 1994 [1733], p. 52). A second factor was the impact of the pedagogues of experimental philosophy, John Theophilus Desaguliers and Willem 's Gravesande, on Abbé Jean-Antoine Nollet during his visits to England and Holland around 1734.[13] The fruit of this was Nollet's first lecture course in experimental philosophy advertised in his brochure *Cours de physique expérimentale chez M. l'abbé Nollet* in 1735, followed by his *Programme ou idée générale d'un cours de physique expérimentale* which appeared in 1738. Given Nollet's standing and connections within the Parisian scientific community, this effectively marks the incorporation of French pedagogy in experimental philosophy into the French scientific establishment.

It is perhaps worth digressing here to point out that similar developments were taking place in Padua, Italy. In February 1739, Giovanni Poleni was appointed to a new chair of experimental philosophy at the university and began teaching experimental philosophy there after the manner of 's Gravesande and Musschenbroek.[14] As far as we have been able to determine, this was the first chair in experimental philosophy in Europe.

Returning to France, 1736 saw the publication of André-François Deslandes' *Recueil de différens traitez de physique et d'histoires naturelles* which opens with a long discourse on the method of experimental philosophy, containing what is arguably the first French philosophy of experiment.[15] It was reissued separately in 1744 under the title *Avertissement, ou discours sur la manière la plus avantageuse de faire des experiences*. A substantially revised version of this discourse appeared in 1748, which opens in the following manner:

> All those who have taste and who know how to think, agree today that there is no real natural philosophy, other than experimental natural philosophy. It alone can enlighten the mind, and fill it with solid, invariable knowledge, drawn from the very bosom of nature. The most famous systems, the most ingenious hypotheses, are only romances where the truth is drowned in an infinity of frivolous conjectures, and thoughts thrown to chance. (Deslandes 1748, pp. 175–6)

Deslandes' *Recueil*, as its title suggests, contains a number of natural histories. They are written in the Baconian style and even include a history of winds in the tradition of Bacon in the second volume, which appeared in 1750.[16]

The year after the first edition of Deslandes' *Recueil* was published, the Marquis d'Argens published his *La philosophie du bon-sens* (1737) which shows a keen grasp of the nature and impact of experimental philosophy, claiming the study of nature 'in these last times is entirely given over to

[13] See Carpenter 2011, p. 38.
[14] See Soppelsa 1989; Talas 2013, esp. pp. 50 and 56.
[15] Deslandes 1736, pp. 1–86.
[16] Deslandes 1750, pp. 177–212. The history of winds begins with a quote from Bacon's *De augmentis scientiarum*, Deslandes 1750, p. 178.

experimental philosophy' (D'Argens 1737, p. 201). It is hardly surprising then that in 1739 the reviewer of volume IV of Abbé Pluche's *Spectacle de la nature* in the *Observations sur les ecrits modernes* refers to the distinction between experimental and speculative natural philosophy and speaks of *physique expérimentale* as that 'which is today so à la mode' (Desfontaines and Granet 1739, p. 101).[17] Indeed, by the mid-eighteenth century it had become commonplace in France to distinguish between experimental and speculative natural philosophy.

The first chair in experimental philosophy was established in 1753 and held by Abbé Nollet, who was appointed as Royal Professor of Experimental Natural Philosophy at the College of Navarre (Professeur Royal de Physique Expérimentale au Collège de Navarre).[18] His 'Discours' given at his installation at the new École de Physique Expérimentale provides an insight into how he viewed natural history and its relation to experimental philosophy. In his first public statement of his conception of natural philosophy, Nollet tells us that:

> The object of experimental natural philosophy is to understand the phenomena of nature and to show its causes by factual proofs. It differs from natural history in that the latter, without rendering reasons for effects, has as its principal aim to give to us a detailed understanding of the bodies of which the universe is composed, to distinguish for us its genuses, species, individual varieties, the relations that pertain between them, and their different properties. The first of these two sciences undertakes to unveil to us the mechanism of nature, the latter to offer us, so to speak, an inventory of our riches. These two are so interconnected that it is near impossible to separate them. The natural philosopher who is not a naturalist is a man who reasons randomly about objects that he does not understand. The naturalist who is not a natural philosopher only exercises his memory. (Nollet 1759, p. xlvii)

Nollet clearly regards *physique expérimentale* and natural history as complementing each other, though as discrete disciplines. His description of natural history as offering 'an inventory' of the riches of nature, giving us a detailed understanding of 'the species, the individual varieties, the relations that pertain between them and their different properties', indicates that he is viewing it as classificatory natural history and not as Baconian natural history.[19]

This is reinforced by the snapshot of natural philosophical pedagogy that we can glean ten years later from the advertisements in the *État ou Tableau de la*

[17] See also Desfontaines and Granet 1739, p. 226 for the distinction between 'physique spéculative' and 'physique expérimentale'.

[18] It is worth recalling that in England the Plumian Chair in Astronomy and Experimental Philosophy was established in Cambridge in 1708 and first held by Roger Cotes.

[19] Nollet had worked alongside René-Antoine Réaumur, the leading natural historian in France in the early 1730s.

ville de Paris of 1763. There, among the list of *Cours publics*, we find courses in *Mathematiques naturelles*, *Histoire naturelle*, *Chymie*, and *Physique expérimentale*. The course in natural history was to be given by Jacques-Christophe Bomare de Valmont and covered minerals, plants, animals, and some productions of art.[20] The public course in *physique expérimentale* was to be given by Abbé Nollet in the Collège de Navarre, and in addition he was to give a private class 'aux Galeries du Louvre'.[21] It is pretty clear that *physique expérimentale* and *histoire naturelle* are considered to be different subjects. In contrast to the situation in late seventeenth-century Britain, in mid-eighteenth -century France natural history and experimental philosophy were discrete, though complementary disciplines.

5.3 Anti-system Sentiment in France

It is well known that at least from the 1730s an anti-system sentiment pervaded French intellectual life. This should be viewed as a legacy of the experimental philosophers' opposition to speculative philosophy and premature systematising in general. In fact, there is an abundance of evidence for the spread and uptake of this stance towards systems, and while space prevents us from tracing it here, it is worth selecting some points on the trail of evidence in France so as to show that this was not solely a British phenomenon. We begin with Fontenelle, Secretary of the Académie des Sciences, who as we noted in Section 5.1, endorsed the two-step method in 1699: 'the Academy is only at the stage of gathering an ample store of well-founded observations and facts, which will one day become the basis for a System' (Fontenelle 1708, sig. Ciij^{r-v}). Moving forward to 1731, we find a clear statement of the standard position of the experimental philosophers in the classicist Nicolas Fréret's 'Reflections on the study of ancient history':

> Philosophers understand by this word 'system' an assemblage of certified facts, demonstrated truths and evident propositions, which, linked together in a natural and necessary relation, form a single body of knowledge, all parts of which support one another and lend each other a reciprocal strength and clarity. Therefore the value of a system depends upon the position and strength of each one of its parts; if any one gives way, the whole edifice will soon crumble and collapse of its own weight.
> (Pocock 1999, p. 158)

Fréret's definition of 'system' is fairly close to the standard theory of a *scientia* or demonstrative science, and he is well attuned to the danger of the principles of such a system being undermined. He goes on to claim that the new method

[20] Anon. 1763, pp. 192–3.
[21] Anon. 1763, p. 194.

of natural philosophy is that which ought to be employed in the study of history:

> I do not mean in what I say here [in the previous two paragraphs] to confuse the love of system with that of the philosophical spirit [*esprit philosophique*] which the exact sciences have brought to the fore in our own age. Of this there is no better evidence than the record of the two most renowned philosophical societies in Europe: the Royal Society in London and the Academy of Sciences in Paris. . . . The spirit of philosophy is very different from the spirit of system; the former is as necessary as the latter is dangerous. . . . True [historical] criticism is nothing other than [natural] philosophic enquiry applied to the study of facts.
>
> (Pocock 1999, pp. 159–60, modified)

Continuing chronologically, Voltaire in his *Lettres philosophiques* criticised Descartes for 'handing himself over to the spirit of system' (Voltaire 1734, p. 128).[22] Interestingly, in the contemporaneous English edition, this passage claims Descartes 'gave entirely into the Humour of forming Hypotheses' (Voltaire 1994 [1733], p. 65). Deslandes, likewise, could say in 1736: 'To embrace a system today is virtually to condemn oneself to see things with a certain bias only and to avoid seeing them otherwise; it is to put on your eyes a glass tinted with a particular colour, without caring whether this glass will alter the objects, or even tarnish them' (Deslandes 1736, p. 3).[23]

Fifteen years later in the 'Preliminary Discourse' to the *Encyclopédie* of 1751, Jean Le Rond d'Alembert attacked those pernicious systems that are based upon hypotheses and 'frivolous conjectures' in contrast to a true science, such as natural philosophy (*physique*) which 'is . . . confined solely to observations and to calculations'. 'Thousands of experiments prove how dangerous the use of systems is in the other sciences' (PD, p. 95). As for the spirit of systems, d'Alembert claims 'one of our best philosophers seems to have delivered the death blow to it' (PD, p. 94). That philosopher is, of course, Condillac, whose *Traité des systèmes* was published in 1749. Condillac himself was not opposed to the construction of systems *tout court*:[24] for him, the issue was getting the right set of principles. It was only principles deriving from matters of fact that provided a firm basis for systematic philosophy. Importantly, he devotes a whole chapter to the formation of political systems in his *Traité*.[25] These, he maintains, are transient and must be formed on the basis of a close study of the people and customs involved.

[22] 'Se livra à l'esprit de Systême'. See also Beattie 1770, p. 417.

[23] 'Embrasser un sistême aujourd'hui, c'est presque se condamner à ne voir les choses que d'un certain biais, et éviter de les voir de tout autre; c'est se mettre sur les yeux un verre teint d'une couleur particuliere, sans s'embarrasser si ce verre altérera les objets, ou même s' il les ternira.' See also Deslandes 1748, pp. 175–6, quoted on p. 154 above.

[24] See Hine 1979.

[25] Condillac 1749, chapter 15.

The anti-system posturing amongst French philosophers and intellectuals more generally is best interpreted as the Francophone analogue of the opposition to speculative philosophy, and in particular the anti-hypotheticalism, of Anglophone experimental philosophers and their supporters. All parties were committed to some form of the neo-Aristotelian theory of knowledge acquisition whereby a science or *scientia* is demonstrated from certain and true principles. The rub was not simply how to avoid 'systems' or theories founded upon false principles, such as those attacked by Condillac in his *Traité des systèmes*, but how to get epistemic access to those true and certain principles.

5.4 Buffon and the Baconian Theory of Natural History

It is now time to turn to a pair of leading French *philosophes* and try to determine the extent to which their understanding and practice of natural history reflects the impact of experimental philosophy and the Baconian theory of natural history. The first *philosophe* is Buffon, French natural historian par excellence and the editor of the massive thirty-six-volume *Histoire naturelle, générale et particulière* which appeared from 1749 to 1767. The temptation here is merely to set out a point-by-point comparison between Bacon's and Buffon's conceptions of natural history, but this runs the danger of oversimplifying the situation. As we saw in Chapter 3, the Baconian method of natural history originated with Lord Verulam but was developed and elaborated throughout the latter half of the seventeenth century. Buffon's exposure to and models of Baconian natural history were hardly restricted to the writings of its progenitor and were framed within his appropriation of the new experimental philosophy.

Buffon, like Voltaire and Nollet, appears to have committed himself to experimental philosophy in the mid-1730s. We quote from the Preface to his 1735 French translation of Stephen Hales' *Vegetable Staticks*:

> The novelty of the discoveries and the majority of its [Hales' book's] ideas will no doubt surprise natural philosophers. I know nothing better in its genre, and the genre itself is excellent, for it is exclusively experiment and observation.
>
> . . . works founded on experiment, merit more trust than others. I can even say that in natural philosophy [*Physique*], one ought to search out experiments as much as one ought to be afraid of systems. I admit that there is nothing so good as to establish first a single principle, and then to explain the universe, and I am convinced that if one were so happy to divine it, all the trouble that we take to make experiments would be unnecessary. But it is plain enough to sensible people the extent to which this idea is vain and chimerical: the system of nature possibly depends upon several principles, principles that are unknown to us and their combination no less so.

> . . . It is by choice experiments, reasoned and monitored, that one forces nature to reveal its secrets. All the other methods have never succeeded
>
> . . . Collections of experiments and observations are therefore the only books that can augment our understanding. Being a natural philosopher is not a matter of knowing what might follow from this or that hypothesis, by supposing, for example, a subtle matter, vortices, an attractive force, etc. It is a matter of having a good knowledge of what happens and a good understanding of that which is presented to our eyes. The understanding of effects will lead us gradually to that of their causes and we will no longer fall into the absurdities that seem to characterise all systems.
>
> . . . It is this method that my author [Hales] followed. It is that of the great Newton; that which Verulam, Galileo, Boyle, Stahl recommended and embraced; that which the Académie of Sciences has taken on as its law to adopt. (Buffon's Preface to Hales 1735, pp. iii–vi)

Clearly this passage is replete with the rhetoric of experimental philosophy: the emphasis on experiment and observation; the decrying of systems and hypotheses; the tracing of a lineage from Bacon to Boyle and Newton. There is no doubt that this passage concerns natural philosophy.[26] The *Dictionnaire philosophique ou introduction à la connoissance de l'homme* of 1751 defines 'physique' as follows: 'Natural philosophy is the knowledge of the causes and effects of nature. It is experimental or conjectural. Experimental natural philosophy is certain knowledge; conjectural natural philosophy is often only ingenious. The one conducts us to the truth, the other leads to error' (Anon. 1751, p. 261).[27] This is an absolutely standard definition of 'natural philosophy' in the period. We saw it above in Nollet, and one finds it, for example, in Desaguliers' *Lectures of Experimental Philosophy* of 1719: 'Natural *Philosophy* is that Science which gives the Reasons and Causes of the Effects and Changes which naturally happen in Bodies' (Desaguliers 1719, p. 1). Furthermore, the *Dictionnaire* is defining *physique* in a manner identical to John Dunton in the passage quoted at the beginning of Chapter 1: there are two types of natural philosophy, experimental and speculative.

It is clear then that in the mid-1730s, Buffon embraced experimental philosophy. But what was his view of the Baconian method of natural history? To answer this we must first turn to Buffon's 'Premier discours: De la manière d'étudier et de traiter l'histoire naturelle' of 1749, which is the most important site for his views on the nature and rationale of the study of

[26] *Pace* Thierry Hoquet (2010, pp. 39–41) who claims, *contra* Phillip Sloan, that *physique* in Buffon's Preface to the translation of Hales should not be translated as 'natural philosophy' because this 'Newtonizes' Buffon.

[27] 'La Physique est la connoissance des causes & des effets de la nature: elle est expérimentale, ou conjecturale. La Physique expérimentale est une connaissance certaine; la Physique conjecturale n'est souvent qu'ingénieuse; l'une nous conduit à la vérité, & l'autre nous mene à l'erreur.' See also the earlier 'The Natural Philosophy, *La Physique*', in Anon. 1719.

natural history.[28] This discourse is the introductory methodological statement that prefaces the entire *Histoire naturelle*. It spells out Buffon's theory of natural history. Indeed, it is one of the only detailed theories of natural history to be developed in France in the period, and it was a work that was widely discussed by subsequent generations of philosophers. Our task is to determine the extent to which it is influenced by or has echoes of the Baconian theory of natural history.

The 'Premier discours' opens with a statement of the size and scope of natural history:

> Natural history, taken in its fullest extent, is an immense subject. It embraces all objects which the universe displays to us . . . A single division of natural history, such as the history of insects . . . is vast enough to occupy the attention of many men. The objects which these particular branches of natural history present are so multitudinous that the most capable observers, after many years' work, have given only very imperfect rough outlines of those branches to which they have been singularly devoted. (Lyon and Sloan 1981, p. 97)

Buffon's claims here about the immense size of the project and the difficulty of bringing it to completion are Baconian themes, though they are themes that had become a commonplace in early modern natural history and philosophy by the early eighteenth century. What is more distinctive, however, is Buffon's claim about the scope of natural history: 'it embraces all objects which the universe displays to us'. This comprehensive scope is, we believe, distinctively Baconian, though it is a feature of Bacon's theory that was not always explicitly acknowledged by neo-Baconian practitioners in the late seventeenth century.

It is worth pausing on this point of scope, for where we see continuity with the Baconian project that had faltered toward the end of the seventeenth century, Phillip Sloan regards this as a true innovation on Buffon's part. He claims that Buffon was 'the foremost architect of this new "natural history"' because he 'broadened and altered' natural history such that it 'eventually resulted in a synthesis of cosmological, geological, historical, and biological questions'.[29] What Sloan has in mind here is Buffon's controversial second discourse, which was concerned with the theory of the generation of the Earth. But this was hardly an innovation on Buffon's part. John Woodward, for example, provides just such a cosmogony in his *An Essay toward a Natural History of the Earth* in 1695, a work which is explicitly developed according to the Baconian theory and had gone through three editions by 1723, and, more importantly, which Buffon himself is at pains to critique in the second

[28] Buffon 1749–89, 1, pp. 3–62.

[29] Sloan 2006, p. 913. There is a long tradition of interpreting Buffon as an innovator in this regard. See Dieckmann 1977, pp. 100–1.

discourse.[30] Indeed, many of the heads of Buffon's natural history are responses to the desiderata laid out in Bacon's *Parasceve*. Buffon's second discourse in Volume 1 on the history of the Earth, to take just one example, includes histories of inequalities of the Earth's surface (*Parasceve* title 18), rivers (title 19), seas and lakes (titles 18–19), the flux and reflux of the sea (title 20), winds (title 6), and so on. What we have in Buffon, then, is not an innovation but a reinstatement of the Baconian scope of natural history. And Buffon does not restrict himself to Bacon's generations; he also shows a keen interest in pretergenerations, as the many references to deformities and monstrous births testify.[31]

Returning to the 'Premier discours' we soon find more Baconian resonances. Early on, Buffon warns against the danger of premature systematising and of starting out with a system in mind:

> a beginning should be made by observing things often and by frequently reexamining them ... The essential thing is to fill the heads of such beginners with ideas and facts, and thus prevent them, if possible, from prematurely establishing schemata. ... if you have resolved to consider things only from a certain point of view, or in a certain order, or in a certain system, although you may have taken the best road, you will never arrive at the same breadth of knowledge to which you might lay claim if, at the outset, you allowed your mind to follow its own lead.
> (Lyon and Sloan 1981, pp. 98–9)

We note too, the prescriptions for the style of writing a natural history:

> Even the style of the description ought to be simple, clear, and measured. The nature of the enterprise does not allow of grandeur of style, of charm, even less of digressions, pleasantries, or equivocation. The sole adornment permitted is nobility of expression, of choice, and of propriety in the use of terms. (Lyon and Sloan 1981, p. 109)[32]

Buffon is opposed to the 'vast amount of useless erudition with which they [natural histories of the past] purposively stuff their works', but unlike Bacon, Boyle, and Hooke, he is able to commend recent natural history for 'eliminating' this 'particular failing' (Lyon and Sloan 1981, pp. 109, 110). He may well have had some of

[30] See the French composite edition of Woodward's main writings on the history of the Earth, Woodward 1735.

[31] See, for example, 'Os difformes', Buffon 1749–89, 3, pp. 53–64. It is worth pointing out that, in keeping with the Baconian method of natural history, Buffon made extensive use of travel literature in the *Histoire naturelle*. See, for example, in Volume 3, 'Momies' and 'Variétés dans l'espèce humaine', pp. 282–96 and 371–530.

[32] Given that he cites both Bacon's *Historia vitae & mortis* (*Histoire naturelle*, 2, p. 309) and Bacon's exemplar natural history of heat in Book II of the *Novum organum* (*Histoire naturelle*, 1, p. 82), there is no doubt that Buffon was aware of the style and content of Bacon's exemplar histories.

the British contributions to the project of Baconian natural history in mind here. For in his history of winds (Volume 1, articles XIV and XV), which bears close parallels with Bacon's own *Historia ventorum*, Buffon cites an article by Edmund Halley from number 192 of the *Philosophical Transactions* of 1691 on the circulation of watery vapours of the sea. In this article, Halley assures his readers that his theory of springs in this paper 'is not a bare *Hypothesis* but founded on Experience'.[33] It is also important to add at this juncture that Buffon, in keeping with his commitment to experimental philosophy, was opposed to system-building and hypotheses and he spends most of the second discourse of Volume 1 of the *Histoire naturelle* defending his cosmogonical theory against the charge that it is a mere hypothesis.[34]

In his history of rivers in the second discourse (1, p. 360), Buffon cites Robert Boyle's *Experiments and Observations upon the Saltness of the Sea*, from volume 3 of Peter Shaw's 1725 'Abridged' and 'methodized' edition of Boyle's works. Interestingly, this volume is divided into three sections: natural history, chymistry, and medicine. The biggest section is natural history, and this is an unashamed reconfiguration, truncation, and compilation by Shaw of many of Boyle's natural historical writings. It presents itself as Boyle's comprehensive natural history, and this too bears a number of structural parallels with Buffon's project.

Turning from the genre, structure, and style of the *Histoire naturelle*, Buffon tells us in the 'Premier discours' that 'the sole true science is the knowledge of facts'.[35] He goes on:

> The mind itself is unable to provide this, and facts are in the sciences what experience is in ordinary life. The sciences might thus be divided into two principal classes which could contain all that is suitable for man to know. The first class encompasses the history of man in society, and the second, natural history. Both are founded upon facts.

This is, of course, the distinction between civil history and natural history which, while not peculiar to Bacon, was a prominent theme in his *De augmentis scientiarum*.[36] Buffon then articulates his view of the utility of natural history:

> it is certain that natural history is the source of the other physical sciences and the mother of all the arts. . . . all the ideas of the arts have their models in the productions of nature. God created, and man imitates. All the inventions of men, whether they be necessities or conveniences, are only grossly executed imitations of that which nature makes with the utmost finesse. (Lyon and Sloan 1981, pp. 110–11)[37]

[33] Halley 1691, p. 471. For Halley's earlier history of winds (Halley 1687), see Section 3.5 above.
[34] See Loveland 2001, p. 101.
[35] Lyon and Sloan 1981, p. 110.
[36] Bacon, *De augmentis scientiarum*, SEH 4 293–314.
[37] See Bacon OFB 12 13. The view that the fine arts are the products of imitation was popularised by Charles Batteux. See Batteux 2015 and PD, pp. 36–8 and 43–5.

Here, natural history à la Bacon, is the source of other sciences and, using Bacon's metaphor, the mother of all the mechanical arts.[38]

Buffon's claim here bears importantly on the interpretation of Thierry Hoquet, who is at pains to differentiate Buffon's conception of natural history from that of Bacon. For Hoquet, what differentiates the two is that Buffon 'appeared to dismiss the Baconian conception in his declaration that he was not aiming for the mere collection of facts';[39] that Bacon 'maintained that it was not necessary that natural history respect any kind of order'; that, for Bacon, to do natural history is to 'just gather data, without claiming any sort of interpretation . . . it would abandon any attempt to look for causes and stick to the act of gathering facts'.[40] In fact, Hoquet claims that on the Baconian approach there are really two sciences of nature: a descriptive one and a philosophical one.[41] By contrast, according to Hoquet, Buffon 'broadened it to the philosophical theory of nature', 'transcending the Baconian herd's hamstrung empiricism' by offering 'the interpretation of nature that was the ultimate and avowed aim of Bacon's *Instauratio*'.[42]

What are we to make of this? First, if this is Buffon's view of his project, then it must be implicit: he nowhere openly criticises the Baconian method. In fact, his criticisms of past natural history echo Bacon's own criticisms. Second, Buffon's claim that natural history is 'the source of the other physical sciences' and his warnings against premature systematising, as well as his defence of his own cosmogonical hypothesis, do appear to be an explicit commitment to the doctrine that natural history is a propaedeutic to natural philosophy and not natural philosophy itself. Third, the relation between the content of natural history and natural philosophical theory was a vexed issue for the neo-Baconian practitioners of his method. Some, like Locke, claimed that, because of our lack of epistemic access to the inner natures of things, natural history is constitutive of experimental natural philosophy.[43] This was not Bacon's position, and nor does it appear to have been Buffon's. Others claimed that experimental philosophy, practised by constructing natural histories, must be complemented by speculative natural philosophy, or at least that there needs to be a creative interplay between the two. Bacon, for his part, set his theory of natural history in the context of a rich heuristic that was to lead to the interpretation of nature, a heuristic that did involve the ordering, sifting, and filtering of facts and experiments. This is the concern of Book II of the *Novum organum* and is

[38] Buffon gives the example of medical remedies as an invention of art, see Lyon and Sloan 1981, p. 110.
[39] Hoquet 2010, p. 45.
[40] Hoquet 2010, p. 46.
[41] Hoquet 2005, pp. 77–8.
[42] Hoquet 2005, p. 47.
[43] See Anstey 2011a, pp. 81–4.

quite inconsistent with the claim that there are two sciences of nature. It is difficult, therefore, to justify the claim that Buffon is differentiating himself from Bacon and that he regards his form of natural history to be an advance on the Baconian view. In our view, Hoquet has not provided enough evidence to establish his case: the continuities between Buffon and the Baconian theory far outweigh the discontinuities.

Yet there are discontinuities. What is distinctive is a greater role for analogical reasoning and a cautious openness to the use of hypotheses. This is best illustrated through Buffon's discussion of the nature of experimental philosophy at the end of the 'Premier discours', which itself is illustrated in his treatment of animal generation.

Buffon begins by claiming that the ancients had no conception of experimental philosophy: 'they did not have any idea of that which we call particular and experimental natural philosophy [*Physique particulière et expérimentale*]' (Buffon 1749–89, 1, p. 50). Instead of restricting ourselves to 'exact descriptions and only the assurance of particular facts in the study of natural history' (p. 50), as the ancients did, we ought to strive for something greater, namely, 'to combine observations, to generalise from the facts, and to link them together by the force of analogies and try to arrive at a higher degree of understanding' (p. 51).

Buffon then sets this method out in more detail by contrasting it with the application of mathematics. There are two sorts of truths, according to Buffon, mathematical truths and physical truths. The former are merely truths of definition and are not made true by things in the world. They are, however, absolutely certain (Buffon 1749–89, 1, p. 54). Physical truths, by contrast, depend on facts, that is, on the way the world is. As such they are only probable but possess a probability that is virtually equivalent to certainty (p. 55). Now, some phenomena or physical truths are regularities: phenomena that repeat themselves in a uniform manner. To them we apply experimental philosophy: 'after having determined the facts by repeated observations . . . after having established new truths by exact experiments, we want to search out the reasons for these same facts, the causes of these effects' (Buffon 1749–89, 1, p. 57), but we normally can only determine the effects and not the underlying causes. Other phenomena are particular: they are those for which we cannot establish any regularities in nature.

The optimal method in science is to combine mathematics and natural philosophy (*Physique*) (Buffon 1749–89, 1, p. 58), but this has only proved possible in a small number of disciplines, such as astronomy and optics. Where mathematics cannot be applied, there we must proceed by experimental philosophy (*Physique expérimentale*), the true aim (*le vrai but*) of which 'is to make experiments on all things that we cannot measure by calculation, on all effects of which we do not yet know the causes, and on all properties, the

circumstances of which we are ignorant. This alone can lead us to new discoveries' (p. 60).

Thus, if the subject matter is too complicated for the application of mathematics, as in the case of natural history and the natural philosophy of particular phenomena [*Physique particulière*], we must resort to experimental philosophy:

> The true method of conducting our mind in these researches is to have recourse to observations, to assemble them and to make new ones from them, and in so great a number as to assure us of the truth of the principal facts, and only to employ the mathematical method to estimate the probabilities of consequences that one can draw from these facts. And above all it is necessary to try to generalise them and to distinguish those which are essential from those which are only incidental . . . it is necessary next to tie them together by analogies, to confirm or destroy certain equivocal points by the method of experiments and to form a plan of explication by the combination of all these relations and present them in the most natural order. (Buffon 1749–89, 1, p. 62)

Buffon then promises to apply this method in the discourse that follows on the theory of the Earth, the formation of the planets, and the generation of animals. The last of these brings us to our final remarks on Buffon, namely, his conception of the role of hypotheses.

One of the most widely discussed features of Buffon's philosophy is his theory of generation. Our concern here is not with that theory per se, but rather with the comments that he makes on hypotheses as he introduces his novel theory. We pick up the discussion at the point where he justifies his use of hypotheses.

Buffon begins by setting out a number of different types of questions about generation. First, there is the question as to *why* animals reproduce. Seeking an answer to this is futile. Second, there is the question as to *how* animals reproduce. The answer to this question requires a natural history of the reproduction of each animal. However, when we ask a third question, namely, 'What is the secret method that nature employs for the reproduction of some beings?', in this case we are permitted to use our imagination by forming hypotheses: 'By this question it is therefore permitted to make some hypotheses and to choose that which is the most analogous to the other phenomena of nature' (Buffon 1749–89, 2, p. 12).

Sensitive to the anti-hypothetical sentiment in his milieu, indeed in his own earlier writings, Buffon is at pains to point out the sorts of hypotheses that he is avoiding and to justify his deployment of a hypothesis in this case. He precludes hypotheses that 'suppose the thing already done' such as *deus ex machina* type explanations (p. 12). He precludes any hypothesis that appeals to final causes and appeals to principles such as 'all living things come from eggs' (pp. 12–13). Having cleared the ground of these illegitimate uses of hypotheses and principles, he then, rather circumspectly, proffers his own.

Buffon's qualified endorsement of the use of hypotheses must be assessed within the broader context of shifting attitudes to hypothetical reasoning on the Continent in the mid-eighteenth century. Perhaps the most balanced and sustained treatment of the issue in French is to be found in chapter 4 of Du Châtelet's *Institutions de physique* (1740), which was strongly influenced by the writings of Christian Wolff (see Section 7.2).[44] But enough evidence has been adduced here to establish Buffon's advocacy of experimental philosophy and his debts to the method of Baconian natural history. It is to another *philosophe* with deep Baconian debts that we now turn.

5.5 Diderot and the Baconian Theory of Natural History

There are many sites of methodological reflection in Diderot's writings, not least his wonderful *Thoughts on the Interpretation of Nature* (*Pensées sur l'interprétation de la nature*, hereafter *Pensées*) of 1754, but the entry point for our discussion of the impact of the Baconian theory of natural history on Diderot must begin with the 'Prospectus' that was later appended to the 'Preliminary Discourse' of 1751, which prefaced the first volume of the *Encyclopédie*.[45]

Bacon's system of the sciences is the primary inspiration and model for the structure of the divisions of the sciences developed by Diderot and d'Alembert in the 'Preliminary Discourse'. They openly acknowledge that this is their greatest debt to Bacon. So close, however, is the system that they developed to that of the Lord Chancellor that Diderot provides an appendix to explain just how the two systems differ. Natural history features in both divisions, and while there are subtle variations, it is not too much to say that the editors have taken over the first feature of the Baconian theory almost wholesale: natural history has an almost identical location in the 'Preliminary Discourse' to that in the *De augmentis scientiarum*, even to the point that it is set up in relation to a tripartite-faculty psychology of memory, reason, and imagination.

In fact, Diderot's description of the divisions of natural history is derived directly from the *De augmentis scientiarum* with additions from the *Parasceve* appended to the *Novum organum*.[46] There is a strong emphasis on the facts of nature, similar to that found in Buffon. Moreover, Diderot copies the tripartite division of generations, monsters, and arts. Let us compare his treatment of uniform nature, that is, generations, with that of Bacon.

> The *history of uniform nature* is divided, following its principal objects, into: *celestial history* or *history of the stars*, of *their movements*, *sensible appearances*, etc., without explaining their cause by systems, hypotheses, etc. (It is a matter here only of pure phenomena.) Into *meteorological*

[44] For Du Châtelet on hypotheses, see Detlefsen 2019.
[45] Diderot 1750.
[46] PD, pp. 146–8.

> *history* such as *winds, rains, tempests, thunder, aurora borealis,* etc. Into the *history of the earth and the sea*, or of *mountains, rivers, streams, currents, tides, sands, soils, forests, islands, configurations of the earth, continents*, etc. Into *history of minerals*, into *history of vegetables*, into *history of animals*. Whence results a *history of the elements*, of the *apparent nature, sensible effects, movements*, etc., of *fire, air, earth*, and *water*.
> (PD, p. 147)

Bacon's text runs as follows:

> For the history of Generations is composed of five subordinate parts. First, a history of the *Celestial Bodies*, exhibiting the actual phenomena simply and apart from theories. Second, a history of *Meteors* (including comets), and what they call the *Regions of the Air*; for there is no history of comets, fiery meteors, winds, rains, storms, and the like, which is of any value. Third, a history of the *Earth and Sea* (considered as integral parts of the universe), mountains, rivers, tides, sands, woods, islands, and the shapes of continents as they lie. (*De augmentis scientiarum*, SEH 4 299)

Little wonder that Diderot was accused of plagiarism when the 'Prospectus' was first published in 1750.

Turning next to Diderot's *Pensées*, many scholars have noted its Baconian character. First, like Bacon's *Novum organum*, it is written in aphoristic form. Moreover, we can tell from its title that it is Diderot's own version of Bacon's *interpretatio naturae*, and the content of the work reveals unambiguously that it is written from the perspective of experimental philosophy, even if Diderot sees a more creative interplay of experiment and speculation than many experimental philosophers would allow and especially the anti-system *philosophes* such as d'Alembert and Condillac.

Again, the *Pensées* ends with a series of queries that mimic Newton's queries to the *Opticks* in true Baconian form.[47] The additions to subsequent editions and the open-endedness of the final sections are staples of the genre. It stands to Bacon's *Novum organum*, particularly Book II, as Buffon's *Histoire naturelle* stands to Bacon's natural historical writings, and to Bacon's vision of what an integrated natural history would look like. (Though it must be admitted that the advice Diderot gives on experimenting is reminiscent of Bacon's exposition of *experientia literata* in the *De augmentis scientiarum*.) In sum, the title, the literary forms deployed and the contents, inflected as they are through the central tenets of experimental philosophy, render the *Pensées* a truly Baconian work. It is hardly surprising, then, to find the article on 'Baconisme' in the *Encyclopédie*, published under Diderot's supervision, reproducing word for word Voltaire's view that Bacon was the founder of experimental philosophy: 'in a word, no one before

[47] Diderot 1754, pp. 182–202.

the Chancellor Bacon, was acquainted with experimental philosophy' (*Encycl.*, 2, p. 10 = Voltaire 1734, p. 97).[48]

But later, in his article on 'Encyclopédie' in Volume 5 of the *Encyclopédie*, Diderot reveals a conception of natural history that also parallels that of Buffon. For example, he claims that:

> He who shall undertake the domain of the [mechanical] arts, will not satisfactorily fulfil his mission, for others and for himself, unless he has made extensive study of natural history, and especially of mineralogy; unless he is an excellent mechanician; unless he is well versed in rational and experimental natural philosophy, and unless he has read several courses in chemistry. (Diderot, *Encycl.*, 5, p. 646A)[49]

We note here the close relation between the mechanical arts and natural history that we found in Buffon. Diderot goes on to claim that 'the history of arts is nothing but *applied natural history*' (p. 646A). It is perhaps also worth pointing out that this article is also revealing because it sets out Diderot's opinion of the degree of familiarity of the French reading public with Bacon's leading works. He comments:

> I think I have taught my fellow citizens to read chancellor Bacon; this wise author has been more pored over in the last five or six years than ever before. We are nevertheless far from appreciating the importance of his works; minds are not yet sufficiently advanced. There are too few people in a position to rise to the level of his meditations; and the number will perhaps never increase by much. Who knows whether the *Novum organum*, the *Cogitata et visa*, the book *De augmento* [*sic*] *scientiarum*, are not too far above the average reach of the human mind, to become in any century easy and common reading? Only time can resolve this doubt. (*Encycl.*, 5, p. 647A)[50]

Does this indicate that the level of familiarity with Bacon's theory of natural history among the *philosophes* was minimal before Diderot's promotion of his mentor? He is certainly patting himself on the back, as he does in the appendix on Bacon in the 'Preliminary Discourse'.[51] And Diderot shares Bacon's sense of the immensity and open-endedness of the project of natural history. Early in the *Pensées*, he speaks of experimental philosophy working century after century piling up materials, and even if it were complete how could anyone

[48] While the article on 'Baconisme' is attributed to Abbé Pestre, François Pépin makes a strong case for the view that Diderot was behind the contents of this article. See Pépin 2012, pp. 88–92.

[49] Translation modified from https://bit.ly/3CGoIiv.

[50] Translation from https://bit.ly/3CGoIiv.

[51] PD, p. 159.

possibly comprehend it?[52] Of course, Bacon did conceive of a day when the project of natural history would come to an end, but for Bacon, this will be the day when we have, at last, the resources for constructing a natural philosophy which will give us knowledge of the forms of natural things. Diderot, by contrast, regards natural history as one among the sciences, a science that is currently flourishing, but which will one day cease.

It is this conception of natural history as merely one among the sciences that constitute *physique*,[53] rather than natural history as the master project that is required for the acquisition of *scientiae*, that represents the most significant and decisive departure from the Baconian theory. We have seen this in Nollet and Buffon, the latter of whom was less explicitly Baconian than Diderot. It is this feature of Diderot's conception of natural history, the fact that it is just one among a constellation of scientific disciplines, that signals an end point to the Baconian theory.

The contrast with British natural history of the late seventeenth century is important, for here we have natural history lined up with the other disciplines rather than encompassing them. Natural history is now largely describing and classifying, and experimenting has a general application across all the disciplines and is of greater relevance to some than others. Yet, at the same time, and this is the sense in which French natural history mid-century is transitional, natural history still pertains to all natural phenomena and not merely to the animal, vegetable, and mineral kingdoms. Though even this was changing fast, as one can glean from the divisions of the entries on natural historical topics in the *Encyclopédie*.[54] In all of this, Diderot believed that he was providing in his *Pensées* a series of aphorisms for the interpretation of nature that was to be applied to the history of nature, and other disciplines, in its Baconian form as elaborated in the 'Prospectus'. There is a very real sense then in which, when it comes to natural history, Diderot truly is the last of the Baconians.[55]

5.6 Experimental Philosophy and the 'Preliminary Discourse'

By the middle of the eighteenth century, experimental philosophy was in the ascendancy in France, and few, if any, claimed to be speculative philosophers. One does not have to look far for evidence of the presence of the ESD in their works. We noted in Chapter 1 that in his *Pensées* (1754) Diderot distinguishes 'two kinds of philosophy, the experimental and that based on reasoning' (Diderot 1937, p. 46). In this section, we will examine the *Encyclopédie* and, in particular, its

[52] Diderot 1754, pp. 17–20.
[53] Voltaire says in the article on 'Histoire' in the *Encyclopédie*: '*l'Histoire naturelle*, improprement dite *histoire*, & qui est une partie essentielle de la Physique', *Encycl.*, 8, p. 220.
[54] For an analysis of the articles on natural history in the *Encyclopédie*, see Llana 2000.
[55] For further discussion of Diderot's Baconianism, see Pépin 2012.

methodological preface with a view to ascertaining the extent to which the methodology it develops reveals an adherence to experimental philosophy. The *Encyclopédie* was a massive undertaking and involved many of the finest minds in France. It aimed to present an up-to-date survey of all knowledge; its seventeen volumes contained some 74,000 articles by around 130 authors, and it was published between the years 1751 and 1772.[56] But of special interest is the fact that it contains an extended preface that is widely regarded as a statement of the methodological position of the editors of the whole project, Jean Le Rond d'Alembert and Denis Diderot. This 'Preliminary Discourse' was written by d'Alembert and, while it reveals the influence of Diderot at various points, it is substantially the work of his younger collaborator.

The 'Preliminary Discourse' provides an ideal test case of the status of experimental philosophy in mid-eighteenth-century France for five reasons: first, because it aimed to be a general position statement of the methodology underlying the *Encyclopédie* project; second, because the 'Preliminary Discourse' contains a potted history of modern philosophy from the time of Bacon and reveals the way in which leading experimental philosophers such as Newton were understood; third, because at a number of crucial points d'Alembert grafted his own earlier methodological writings into it, and as a result it gives us a reference point from which to examine his own methodological views; fourth, because it shows the influence of other contemporary French *philosophes* such as Condillac and Diderot himself and so provides a window through which we can view a broader range of views and influences than merely those of d'Alembert; and fifth, because it generated further methodological reflections, not least Diderot's own *Pensées*.

The obvious place to start is with the key terminology and theses associated with experimental philosophy. In the 'Preliminary Discourse', d'Alembert uses the term 'Physique expérimentale' to refer to experimental philosophy. The term appears six times, always capitalised. Here is a summary of what he has to say about it. Early in Part One, after discussing the example of the magnet whose magnetic property remains unknown to us, d'Alembert says:

> The only resource that remains to us in an investigation so difficult, although so necessary . . . is to collect as many facts as we can, to arrange them in the most natural order, and to relate them to a certain number of principal facts of which the others are only the consequences. . . . Such is the plan that we must follow in that vast part of natural philosophy called General and Experimental natural philosophy [Physique générale & expérimentale] . . . it is properly only a reasoned collection of experiments and observations. (PD, pp. 23–4, modified)

[56] In addition, the *Encyclopédie* included eleven volumes of plates.

The Baconian resonances here are striking: 'collect as many facts as we can'; 'arrange them in the most natural order'; 'Experimental natural philosophy . . . is properly only a reasoned collection of experiments and observations'. This could have been taken from the *Novum organum* or from Book Four of Locke's *Essay concerning Human Understanding*, for this describes the basic procedure of the Baconian method of natural history. It is hardly surprising then that the next reference to *Physique expérimentale* says as much: 'In his *Novum Organum*, he perfects the views that he had presented in the first book [*Advancement of Learning*], carries them further, and makes known the necessity of *Physique expérimentale*, of which no one was yet aware' (PD, p. 75, modified). This is the science developed by Locke, who 'reduced metaphysics to what it really ought to be: the *Physique expérimentale* of the soul' (PD, p. 84); that is, Locke's *Essay* is an example of experimental philosophy applied to the understanding. This *Métaphysique raisonnable*, or metaphysics of reason, consists 'as does *Physique expérimentale*', in 'reducing [the phenomena] to a corpus of information, in explaining some by others, and in distinguishing those which ought to hold the first rank and serve as the foundation' (PD, p. 84).[57] But this science has hardly progressed 'because of the natural temptations that prevent us from holding ourselves within bounds when we engage in metaphysical speculations'. Who might the originator of this new form of philosophy that avoids 'metaphysical speculations' be? The next reference makes it quite clear: Boyle was 'the father of experimental natural philosophy' (*le pere de la Physique expérimentale*) (PD, p. 86).[58]

Turning to the *Encyclopédie* itself, we find the term *Philosophie expérimentale* in d'Alembert's article on 'Expérimental' in volume 6. D'Alembert defines it as follows: 'we call experimental philosophy that which uses the way of experiments to discover the laws of nature' (*Encycl.*, 6, p. 298).[59] From his subsequent comments, it is clear that he regards it as synonymous with *Physique expérimentale*.

Another facet of early modern experimental philosophy is its opposition to hypotheses and speculation that are not founded upon observation and experiment. Not surprisingly, the 'Preliminary Discourse' is studded with antagonistic references to speculation and hypotheses. We supply a catena of quotations here:

> In a well-constructed philosophy, any deduction which is based on facts or recognized truths is preferable to one which is supported only by hypotheses, however ingenious.

[57] It is important to note that 'metaphysics' in the mid-eighteenth century often refers to pneumatology or the study of the soul or understanding. This is the sense that d'Alembert has in mind when he says that Locke 'created metaphysics, almost as Newton had created physics', PD, p. 83. For further discussion, see Anstey 2018.

[58] Voltaire had earlier claimed that Bacon was the 'Father of experimental Philosophy' Voltaire 1994 [1733], p. 51.

[59] 'On appelle *Philosophie expérimentale*, celle qui se sert de la voie des expériences pour découvrir les lois de la Nature.'

> It is not at all by vague and arbitrary hypotheses that we can hope to know nature.
>
> [Geometers sometimes] permit themselves to use hypotheses which are most convenient, to be sure, but often very far removed from what really exists in Nature.[60]
>
> The single true method of philosophizing as physical scientists consists either in the application of mathematical analysis to experiments, or in observation alone … aided sometimes by conjectures when they can furnish some insights, but rigidly dissociated from any arbitrary hypotheses. (PD, pp. 7, 22, 24, 25)

The same sentiments also appear in the *Encyclopédie*. Take for example, d'Alembert's article on 'Expérience' in Volume 6, where he says 'speculations more subtle and meditations more profound are only vain imaginations if they are not founded upon exact experiments' (*Encycl.*, 6, p. 297).[61]

In addition to his anti-hypotheticalism, d'Alembert, as we saw above, also opposed to the construction of natural philosophical systems based purely on metaphysical first principles without prior recourse to observation and experiment:

> the taste for systems – more suited to flatter the imagination than to enlighten reason – is today almost entirely banished from works of merit. One of our best philosophers [Condillac] seems to have dealt a death blow to it. The spirit of hypothesis and conjecture formerly was perhaps quite useful … But times have changed, and a writer among us who praised systems would have come too late. (PD, p. 94)

The railing against systems continues:

> The spirit of systems … is almost never capable by itself of leading us to truth. It can glimpse the causes of phenomena when enlightened by the observation of Nature; but it is for calculations to assure, so to speak, the existence of these causes by determining exactly the effects they can produce and by comparing these effects with those revealed to us by experience. (PD, p. 95)[62]

It appears then, that experimental philosophy, and in particular the distinction between experimental and speculative philosophy, is writ large on the 'Preliminary Discourse': it uses the same terminology that we find in English writings that deploy the distinction, and it explicitly states the main theses of the distinction from the perspective of

[60] Hypotheses have no place in natural history either, see PD, p. 147.

[61] 'Les spéculations les plus subtiles & les méditations les plus profondes ne sont que de vaines imaginations, si elles ne sont pas fondées sur des *expériences* exactes.'

[62] See also the article in the *Encyclopédie* on 'Système', *Encycl.*, 15, pp. 777–8. For further discussion of the prehistory of the anti-system debate in France, see Anstey 2018.

proponents of experimental philosophy. We conclude from the foregoing discussion that d'Alembert was a proponent of experimental philosophy and that the ESD provides the fundamental terms of reference by which philosophy is understood in the 'Preliminary Discourse'.

5.7 The Rehabilitation of Descartes

Francis Bacon had long been considered a seminal figure in the emergence of experimental philosophy for at least four reasons: first, because of the central role that he gave to experiment in his account of the nature of natural history; second, because of the detailed and very interesting philosophy of experiment that he discusses in his theoretical works and applies in his natural historical works; third, because of his vision of a natural philosophical society upon which the Royal Society was modelled; and fourth, as d'Alembert points out, because of his opposition to systems.[63] Descartes, as we have seen, was often castigated by earlier generations of experimental philosophers, because his vortex theory of planetary motions came to be regarded as the archetypal speculative theory. By the third and fourth decades of the eighteenth century, brief reflections and histories on the emergence of experimental philosophy invariably included Bacon, Newton (who saw the need to 'banish conjectures and vague hypotheses' (PD, p. 81)), and even Locke, but they hardly ever included Descartes.[64] For example, the Scots Newtonian, Colin Maclaurin, contrasts Cartesianism with experimental philosophy: 'If we attend to the consequences of such [speculative Cartesian] principles, we shall the more willingly submit to experimental philosophy, as the only sort that is suited to our faculties' (Maclaurin 1748, p. 77). Voltaire was even more explicit: 'I avow, in truth, along with all true natural philosophers without exception – with the Newtons, the Halleys, the Keills, the 's Gravesandes, the Musschenbroeks, the Boerhaaves, etc. – that true experimental philosophy [*philosophie expérimentale*] and that of calculation are entirely missing from Descartes' (Voltaire 1877–85, 35, p. 287).[65]

[63] PD, p. 75.

[64] For a somewhat idiosyncratic defence of a vortex theory that appeals to experimental philosophy, see Julius Bate's *Experimental Philosophy Asserted and Defended* (1740).

[65] Voltaire to the Marquis d'Argens, 21 June 1739. See also Voltaire to Maupertuis, Voltaire 1877–85, 35, pp. 3–15, to which letter he refers in the letter to d'Argens. In stark contrast to Voltaire's comment, fourteen years later David Renaud Boullier would write in response to d'Alembert's 'Preliminary Discourse': 'he [Descartes] opened that vast quarry of experimental natural philosophy ... the Boyles, the Newtons, the Leibnizes, the Malebranches, the Fontenelles are his disciples' (Boullier 1753, pp. 23–4).

This is the context in which we need to assess d'Alembert's attempt to rehabilitate Descartes and include him in his history of the emergence of experimental philosophy.[66] Here is how d'Alembert puts it:

> If Descartes, who opened the way for us, did not progress as far along it as his sectaries believe, nevertheless the sciences are far more indebted to him than his adversaries will allow . . . If one judges impartially those vortices which today seem almost ridiculous, it will be agreed . . . that at the time nothing better could be imagined. . . . natural philosophers had to be carried forward almost in spite of themselves by the theory of central forces and by experiments made much later before they would abandon it. . . . it was necessary, so to speak, to pass by way of the vortices in order to arrive at the true system of the world. (PD, pp. 78–9, modified)[67]

But at the same time, d'Alembert was not averse to criticising the excesses of Cartesian speculative natural philosophy.[68] It is fair to say that recent Cartesian scholarship has confirmed the view of d'Alembert and reinstated Descartes as an important stimulus to the emergence of experimental philosophy, through his optics, his physiology, and his mechanics.[69] We, therefore, regard

[66] At least four authors included Descartes among the contributors to experimental philosophy before the publication of the 'Preliminary Discourse'. According to Joseph Glanvill, no one succeeded better than Descartes in applying Bacon's method, that is, 'the way of experiment and induction' (Glanvill 1665, p. 72). The author of a marginal comment to the manuscript *Costituzioni dell'Accademia dei Fisiocritici*, established in Siena in 1691, stated that experimental philosophy is based on views set out in antiquity and adhered to by Galileo, Descartes, and Boyle, among others (Accademia dei Fisiocritici 1691, marginal number 31). The Venetian mathematician Giovanni Crivelli stated in the second edition of his manual of natural philosophy that Descartes employed the experimental method of philosophising, although he also put forward 'daring hypotheses' (Crivelli 1744, p. 21). The scholar Antonio Conti included Descartes among the contributors to experimental philosophy, as well as conjectural and fictional philosophy, in a text written before 1750 (see Introduction, p. 9 n. 19). Additionally, a letter written in 1699 by Giacinto Gimma, a *novator* from Bari who spent time in Naples, includes Descartes among the contributors to experimental philosophy (Tremigliozzi 1700, p. 265). However, Gimma understands 'experimental philosophy' in a very broad sense.

[67] See also d'Alembert 1749, p. xxxviii. For other such brief histories of experimental philosophy, see d'Alembert's article entitled 'Expérimental' in the *Encycl.*, 6, pp. 298–301, which is recycled in *Essai sur les élémens de philosophie*, d'Alembert 1965 [1759], pp. 451–61. For earlier, French evaluations of Descartes that acknowledge his contributions, see Voltaire 1734, pp. 129–30, d'Argens 1737, pp. 17–18, du Châtelet 1740, pp. 5–6 and La Mettrie 1748, pp. 94–5. For Leibniz's early qualified praise of Descartes, see Leibniz to Herman Conring, 19 March 1678, in Leibniz 1969, p. 188.

[68] See especially the humorous *Anti-physique* passage in *Essai sur les élémens de philosophie*, d'Alembert 1965 [1759], pp. 90–4 and 470–1, which has Descartes in its sights. See also Crane 1976, pp. 275–6, and d'Alembert's claim against Descartes and Bacon that they would have been more useful had they been 'plus physiciens de pratique & moins de théorie', *Encycl.*, 6, p. 299.

[69] See, for example, Gaukroger, Schuster, and Sutton 2000.

d'Alembert's inclusion of Descartes in his potted history of the emergence of experimental philosophy as an important corrective to the historiography of experimental philosophy up to this point.

5.8 Conclusion

It is clear from the writings of Voltaire, Nollet, Deslandes, d'Argens, Buffon, Diderot, and d'Alembert, and from the *Encyclopédie* itself, that experimental philosophy was widely endorsed in France by the mid-eighteenth century. This is not to say that it was unknown, opposed, or ignored before then: only that the first widespread endorsement of experimental philosophy is datable to the mid-1730s. Yet, as we might expect, it was refracted through a peculiarly French lens, such that it was modified and expressed in its unique Francophone form. The antagonism between experimental and speculative philosophy, so prevalent in its British manifestation, was largely expressed through the anti-system debate; Buffon's theory of natural history, while clearly a descendant of the method of Baconian natural history, had its own idiosyncratic features; and in general, *physique expérimentale* was regarded in some contexts as a discipline on a par with chemistry and natural history, rather than as subsuming all of the sub-disciplines of natural philosophy.

Moreover, from the mid-1740s there was another important Francophone development within experimental philosophy further east in the Prussian academy of Frederick the Great, one which all but denied any antagonism between experimental and speculative philosophy. This is discussed in Chapter 7 below. Yet geographical expansion was not the only dimension in which experimental philosophy was spreading, for by the mid-eighteenth century it was being applied beyond natural philosophy and medicine to the moral sciences. It is to this development that we now turn.

CHAPTER 6

Experimental Natural Philosophy and Moral Philosophy

A number of leading moral philosophers of the eighteenth century claimed that they were applying the methods of the new experimental natural philosophy to moral philosophy. Take, for example, the striking claim in Helvétius' influential *De l'esprit*: 'I believed that we must treat morals like all the other sciences and do moral philosophy like experimental natural philosophy' (Helvétius 1758, pp. i–ii).[1] This was a most natural development. After all, even natural philosophers could see the relevance of their work for moral philosophy. Isaac Newton, for example, famously claimed in the thirty-first query to the *Opticks*, 'if natural Philosophy in all its Parts, by pursuing this Method [of analysis which consists in making experiments and observations], shall at length be perfected, the Bounds of Moral Philosophy will also be enlarged' (Newton 1979, p. 405).[2] It is hardly surprising, therefore, that those who were practising moral philosophy and keeping an eye on developments in natural philosophy would look for connections between the two.

The aim of this chapter is to provide an overview of the impact of experimental philosophy on the moral philosophers of the late seventeenth and eighteenth centuries. It should be pointed out before we commence, however, that the historical record suggests that there was no clearly defined *movement* of experimental moral philosophy in the period. The impacts of experimental natural philosophy that we will examine are not evident in all moral philosophers and were far from uniform. In point of fact, the evidence of impact is quite varied and is best taken on a case-by-case basis. Of course, there was also some variability in approach and method amongst experimental natural

[1] 'J'ai cru qu'on devoit traiter la morale comme toutes les autres sciences, & faire une morale comme une physique expérimentale.' See also Hooper's note to his translation of *De l'esprit*: 'In morality, as in all other sciences, what should be done before we form a system? Collect the materials necessary for the construction. We cannot now be ignorant, that an experimental morality, founded upon the study of men, and of things, as far surpasses a speculative and theological morality, as experimental philosophy exceeds a vague and uncertain theory', Helvétius 1777, p. 236 n. 17.

[2] Wolff endorses the two-step model of knowledge acquisition for moral and civil philosophy. See Wolff 1740a, §12. Turnbull cited Newton's thirty-first query in his thesis of 1723. See P. B. Wood 1990, p. 131. See also Tunstall 1759, p. 85: 'Every advance therefore in the observation of nature carries with it a proportionable improvement of the moral science.'

philosophers, but their methodology and practice are relatively homogeneous in comparison with the diversity of moral philosophies of the period.

Furthermore, early modern moral philosophy was subject to other influences and trends, both internal and external, over and above the new experimental natural philosophy. These include developments in theology broadly construed and new approaches to the study of human understanding, as well as movements within moral philosophy itself, such as the rise of natural law theory. It is beyond the scope of this chapter to examine the interplay of all these factors. Nor is it possible to survey every moral philosopher. Nevertheless, there is ample evidence that many of the central methodological ideas and forms of reasoning and argumentation of experimental philosophy were taken up and grafted onto moral philosophy in ways that had a profound impact on the forms that moral philosophy took in the period. This chapter explores four definite points of impact of the new experimental philosophy on moral philosophy. It does not presume to be an exhaustive study, but one that suggests lines for further research. Before turning to these points of impact, however, we must address an important point pertaining to disciplinary boundaries.

6.1 Moral Philosophy and the Moral Sciences in the Eighteenth Century

The subtitle to David Hume's *A Treatise of Human Nature*, is 'An Attempt to Introduce The Experimental Method of Reasoning into Moral Subjects'. It is tempting to see this as encapsulating the impact of developments in the new natural philosophy on the moral philosophy of one of the leading figures of the Scottish Enlightenment. However, it is important to note that in the eighteenth century, in both Britain and France, moral philosophy was generally considered to be, not identical to, but rather a subset of, the moral sciences. Thus, Hume's term 'moral subjects' almost certainly refers to the moral sciences and not to the narrower enterprise of moral philosophy. This is borne out by the fact that all but one of the references to experiment in Hume's *Treatise* occur in Books One and Two, which concern the understanding and the passions and not Book Three entitled 'Of Morals'.[3]

While the term 'moral sciences' was used in the seventeenth century,[4] its heyday was in the following century. Various definitions of the term can be found in the eighteenth century, though the semantic domain is easy to specify. Isaac Watts, for example, considers that the moral sciences pertain to the study of man, including the union of body and soul, the sensations, appetites, and passions.[5] This roughly accords with Hume's usage and shows that claims to be

[3] *Treatise* 3.3.1, p. 369. See also pp. 4–5.
[4] See, for example, Locke's *Essay* IV. iii. 20.
[5] Watts 1733, p. iv.

applying the method of experimental natural philosophy to the moral sciences allude to the study of the human understanding, sentiments, and passions as much as to moral philosophy. In France, Condorcet defined the moral sciences as the study of 'the human mind in itself and the relations of men one to another' (Condorcet 1847, p. 410).[6] Later in the century, James Beattie claimed that the moral sciences can be reduced to four disciplines: psychology (what others called pneumatology or the study of the soul), natural theology, moral philosophy, and logic.[7]

The upshot of this is that when we examine claims by particular moral philosophers to be applying experimental methods, we need to determine whether they conceive of the application of those methods as pertaining to the broader notion of the moral sciences, including the acquisition of knowledge about sentiment and the passions, or whether it applies more specifically to the acquisition of knowledge in moral philosophy, such as the grounds of obligation and the nature and content of normative principles. Some philosophers consciously distinguished between the moral sciences broadly construed and moral philosophy narrowly construed, while others worked with a more general conception that included both the science of man and the normative in the one enterprise.

6.2 The Experimental/Speculative Distinction Again

As we saw in Chapter 1, in the early seventeenth century the standard way for scholars to divide the different disciplines or branches of philosophy was into the speculative and practical sciences. As for the disciplines themselves, we also pointed out in Chapter 1 that the most popular division was as follows: metaphysics, natural philosophy, and mathematics were speculative sciences and ethics, politics, and oeconomy (management of the family) were the practical sciences.

It is crucial to note here that natural philosophy is a speculative science and ethics, that is, moral philosophy, is a practical science.[8] With the advent of experimental philosophy in the early 1660s, two decisive changes occurred. First, as we have shown in Chapter 1, for many, natural philosophy ceased to be regarded as a purely speculative science and came to be seen as a practical science, namely, experimental philosophy.[9]

As the first generation of experimental philosophers forged a new methodology of natural philosophy, they set it in opposition to the method that natural

[6] 'L'esprit humain en lui-même, ou les rapports des hommes entre eux'.
[7] Beattie 1790, p. xv.
[8] For example, for Richard Cumberland ethics is a practical science, see Cumberland 2005 [1672], p. 365.
[9] See also, for example, Sprat 1667, p. 257.

philosophers used who still treated it as a speculative science. That is, they *opposed* speculative natural philosophy and, in some quarters, all forms of speculation. This is what lies behind their opposition to philosophical systems and hypotheses. As we have seen, by the end of the seventeenth century this distinction between experimental and speculative natural philosophy was very widespread. In Chapter 1, we cited John Dunton's student manual, *The Young-Students-Library*, published in 1692 which claims, 'Philosophy may be consider'd under these two Heads, Natural and Moral: The first of which, by Reason of the strange Alterations that have been made in it; may be again Subdivided into *Speculative* and *Experimental*' (Dunton 1692, p. vi). Notice here the twofold division. First, there is the distinction between natural and moral philosophy, and second, the division of the former into experimental and speculative (Figure 6.1). One way of construing the aim of this chapter is to regard it as an exploration of how moral philosophers sought to mitigate the first division, between natural and moral philosophy, by appropriating one side of the second division, experimental philosophy. In doing so, the disciplinary and methodological alignments of moral philosophy were reconfigured relative to the current state of natural philosophy rather than to the traditional division between the speculative and practical sciences.

There is ample evidence that moral philosophers of the eighteenth century accepted these distinctions and attempted to incorporate them into their approaches to moral philosophy. For example, Edward Bentham's *An Introduction to Moral Philosophy* of 1745 begins with the following classification:

> The word *Philosophy* is a general name comprehending all the Liberal Arts and Sciences. . . . Of the *principal* branches some are of a *speculative* nature, as *Metaphysicks*, *Natural Philosophy*, *Mathematicks*, &c . . . Another branch of Philosophy is term'd *practical* in a more proper sense, as it has a direct reference to Human *Actions*, points out our duty, and regulates our conduct, that we may become *better* Men.
>
> (Bentham 1745, p. 1)

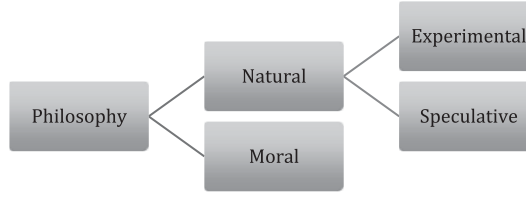


Figure 6.1 The branches of philosophy in the late seventeenth century

He then goes on to list ethics, or moral philosophy, politics, and oeconomics as practical sciences.[10]

In fact, this appropriation of the speculative–practical distinction provides a plausible explanation of what is otherwise an inexplicable phenomenon in some Anglophone moral philosophy of the eighteenth century. For a handful of moral philosophers writing from the mid-eighteenth century conceived of their discipline as comprising two parts, a speculative and a practical part (Figure 6.2). The American Samuel Johnson, for example, writing in 1746, claimed that 'the *Truths* [about human nature] are the *Speculative*: – And the *Duties* are the practical Part of *moral Philosophy*' (Johnson 1746, p. 15). From the perspective of many in the seventeenth century, this would have appeared quite extraordinary. Here, we have the paradigm practical discipline, ethics, a discipline for which there was no prospect of ever being a *scientia* – no prospect of ever being a systematic body of knowledge derived from demonstrative syllogisms and based on necessary principles – being described as comprising a speculative part! What seems to have happened in the minds of those who endorsed this distinction, such as Thomas Reid, Adam Ferguson, and James Beattie[11] in Scotland, and Samuel Johnson in America, is that they

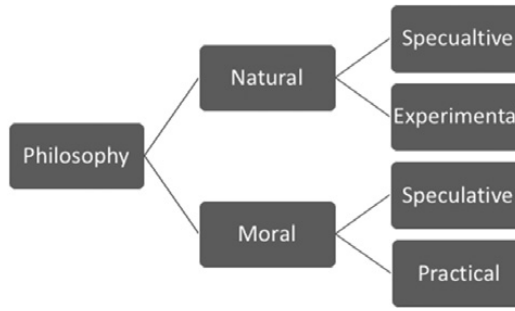


Figure 6.2 Speculative and practical moral philosophy

[10] Bentham 1745, p. 2. The traditional classification of ethics as a practical science and natural philosophy as a speculative science is found in Hume, *Treatise* 3.1.1, p. 294. Another who deployed the speculative–practical distinction was Jean Barbeyrac, see Barbeyrac 1729, p. 1.

[11] Beattie's divisions of knowledge and moral philosophy therein derives in large part from Francis Bacon's *De augmentis scientiarum*. Strangely, this is overlooked by Ablondi in his 2012. One salient point of departure from Bacon, however, is Beattie's division of moral philosophy into speculative and practical parts. He claims that 'it consists, like every other branch of science, of a Speculative and a Practical part' (Beattie 1790, 1, p. xiii; see also 2, p. 7). In this, Beattie is likely following Reid and shows his ignorance of the scholastic divisions of the sciences.

have lost their historical moorings and have reconceived the discipline of moral philosophy with reference to the dichotomy of speculative versus practical *natural* philosophy. Indeed, Thomas Reid goes so far as to invent a historical precedent for this very division of moral philosophy into speculative and practical parts in his claim about Cicero:

> There is in Ethicks as in most Sciences a Speculative and a practical Part, the first is subservient to the last. This Division of Ethicks is very Ancient. . . . Cicero mentions it in the beginning of his Offices and his three books of Offices are a System of practical Ethicks as his five books De Finibus explain the several speculative Systems of the Greek Philosophers on this Subject. (Reid 2007, p. 10, *c*. 1766)

If this explanation of the emergence of the speculative–practical divide in some eighteenth-century moral philosophers is correct, it would imply that what some scholars see as an innovation in Scottish moral philosophy and pedagogy, namely, the writing of manuals of practical ethics and the teaching of practical ethics in the universities,[12] should really be viewed both as a legacy of experimental philosophy and as a historically naive move in some quarters of Scottish moral philosophy. For from the perspective of the seventeenth century, the expression 'practical ethics' is tautologous, because ethics is by its very nature a practical discipline.

6.3 The Critique of Speculative Philosophy: Against Systems and Hypotheses

Not only were moral philosophers well attuned to the distinction between experimental and speculative natural philosophy, many of them sided with experimental philosophy over and against speculative philosophy. There were two familiar facets of this opposition: an antagonism towards systems and a concomitant antagonism towards hypotheses. Let us examine each in turn.

As we have seen, opposition to systems was a feature of experimental natural philosophy from its earliest days. It was not that systematic thinking was rejected *tout court*, but that the construction of systems was to be the final stage of philosophising after the assembling of observations and experiments. Premature systematising was to be avoided. We saw this in Boyle's attitude to systems in Chapter 2: 'That then that I wish for, as to Systems, is this, That men in the first place would forbear to establish any Theory, till they have consulted with . . . a considerable number of Experiments in proportion to the comprehensiveness of the Theory to be erected on them' (B 2 14). A similar sentiment is found in Richard Cumberland, who claimed, 'I have designedly *abstain'd from*

[12] See, for example, C. Heydt 2013; Garrett and Heydt 2015.

any physical Hypothesis concerning the System of the World' (Cumberland 2005 [1672], p. 283).

Another leading moral philosopher who cautioned against systems in political philosophy was Adam Smith. In his *Theory of Moral Sentiments*, he is more concerned with the practical dangers of the spirit of system for the establishment of government and the enactment of public policy. He contrasts the man of public spirit with the man of system:

> The man of system, on the contrary, is apt to be very wise in his own conceit; and is often so enamoured with the supposed beauty of his own ideal plan of government, that he cannot suffer the smallest deviation from any part of it. He goes on to establish it completely and in all its parts, without any regard either to the great interests, or to the strong prejudices which may oppose it. (IV. ii. 17, A. Smith 2002, p. 275)[13]

In *The Wealth of Nations*, however, in his potted history of education from the time of the Greeks, he is critical of the construction of systems in both natural and moral philosophy:

> The beauty of a systematical arrangement of different observations connected by a few common principles, was first seen in the rude essays of those antient times towards a system of natural philosophy. Something of the same kind was afterwards attempted in morals. The maxims of common life were arranged in some methodical order, and connected together by a few common principles, in the same manner as they had attempted to arrange and connect the phenomena of nature. The science which pretends to investigate and explain those connecting principles, is what is properly called moral philosophy.
>
> Different authors gave different systems both of natural and moral philosophy. But the arguments by which they supported those different systems, far from being always demonstrations, were frequently at best very slender probabilities, and sometimes mere sophisms, which had no other foundation but the inaccuracy and ambiguity of common language. Speculative systems have in all ages of the world been adopted for reasons too frivolous to have determined the judgement of any man of common sense, in a matter of the smallest pecuniary interest.
>
> (A. Smith 1776, 2, pp. 352–3)

This is not to claim that Smith was opposed to the construction of systems of moral philosophy. He devotes the entire final Part VII of his *Theory of Moral Sentiments* to a review of such systems. Likewise, Thomas Reid gives a treatment of systems of moral philosophy in his *Essays on the Active Powers of Man*.[14] The point here is that it is the association of systematic

[13] See also *Theory of Moral Sentiments* IV. i. 11, Smith 2002, pp. 216–17.

[14] Reid 2010, pp. 278–90. Reid claims that moral and political philosophy are discrete disciplines, p. 282.

thinking with speculative philosophy that is the danger. And this provides a nice bridge into the second facet of opposition to speculative philosophy, the critique of hypotheses.

It is only a small step from speculative hypotheses, that is, hypotheses not founded on experience, to the construction of speculative systems, yet it was the former that really raised the ire of experimental philosophers. Newton's 'hypotheses non fingo' was a common trope amongst experimental philosophers by the time he penned it in the 'General Scholium' of the second edition of the *Principia* (1713),[15] but given his stature, his endorsement of experimental philosophy, including his rejection of hypotheses and speculation, added enormous credibility to the new natural philosophical methodology. It was still being echoed by Thomas Reid nearly seventy years later when he claimed, 'I have, ever since I was acquainted with Bacon & Newton, thought that this Doctrine [the mistrust of hypotheses] is the very Key to Natural Philosophy, & the Touchstone by which every thing that is Legitimate and Solid in that Science, is to be distinguished from what is Spurious and Hollow' (Reid 2002, p. 140).[16]

Once again, the case of David Hume provides a robust example of its application to moral philosophy. In a well-known passage in the *Abstract* to the *Treatise* he says of himself in the third person, 'he talks with contempt of hypotheses; and insinuates, that such of our countrymen as have banished them from moral philosophy, have done a more signal service to the world, than *my Lord Bacon*, whom he considers as the father of experimental physicks' (*Treatise*, p. 407). This led them to oppose systems of moral philosophy founded upon a priori principles and to oppose the use of hypotheses and speculation in moral philosophy. The position is perhaps best exemplified by George Turnbull's *Principles of Moral and Christian Philosophy* of 1740:

> as in natural philosophy, though it would be but building a fine visionary Theory or Fable, to draw out a system of consequences the most accurately connected from mere hypotheses, or upon supposition of the existence and operation of properties, and their laws, which experience does not shew to be really existent; yet the whole of true natural philosophy is not, for that reason, no more than a system of facts discovered by experiment and observation; but it is a mixture of experiments, with reasonings from experiments: so in the same manner, in moral philosophy, though it would be but to contrive a beautiful, elegant romance, to deduce the best coupled system of conclusions concerning human nature from imaginary suppositions, that have no foundation in nature; yet the whole of true moral philosophy, will not, for that reason, be no more than a collection of

[15] *Principia*, p. 943. John Maxwell quoted this in an appendix to his 1727 translation of Cumberland's *Treatise of the Laws of Nature*. See Cumberland 2005, p. 875.

[16] Reid to Lord Kames, 16 December 1780. See also *Active Powers*, Reid 2010, p. 37 and Reid 1995, pp. 178 and 209.

> facts discovered by experience; but it likewise will be a mixed science of observations, and reasonings from principles known by experience to take place in, or belong to human nature.
>
> In neither case are hypotheses to be any further admitted, than as questions, about the truth or reality of which it is worth while to enquire. (Turnbull 2005 [1740], pp. 62–3)

6.4 Experiment and Observation

Turnbull's references to experiment, observation, and 'facts discovered by experience' bring us to the third impact of experimental natural philosophy on moral philosophy, namely, the attempt to bring observation and experiment to bear on ethical thought.

It appears that no moral philosopher from the late seventeenth or eighteenth century undertook structured experimental investigations with a view to formulating moral theory. We are not aware of any published reports of experimental observations by moral philosophers, there are no new instruments, there are no open debates about the interpretation of empirical results and their normative implications. Yet even a cursory survey of the writings of moral philosophers from the period reveals numerous references to experiments. In order to evaluate the nature and credibility of these references, we must first set out a number of conceptual issues that pertain to the nature of experiment and observation in experimental natural philosophy.

First and foremost, there is the semantic range of the term 'experiment'. It could be used to refer to an active, directed intervention in nature, but it was also used as a synonym for 'observation' and for 'introspection', and even for the more generic notion of experience itself.[17] If all that early modern moral philosophers mean by 'experiment' is introspection or experience, the expectation that their work is somehow a precursor to modern day x-phi is bound to be dashed. Moreover, as we noted in the Introduction, in many cases in early modern natural philosophy the expression 'observation and experiment' is a hendiadys. This implies that for many there was not a clear-cut distinction between observation and experiment and that the coupling of the terms functioned more as a way of capturing all that was relevant to, say, the construction of a natural history or the evidential base on which a theory was to be founded. A helpful way to view the relation between observation and experiment in this case is as a continuum from active intervention on the experimental side to hands-off passive perception on the observational side. We ought though to be

[17] Boyle notes 'the word *Experience* may admit of divers Senses' and in his preferred sense includes 'not only those *Phænomena* that Nature or Art exhibits to our Outward Senses', but also 'those things that we perceive to pass Within our selves' (B 11 307).

wary of generalising here, for some moral philosophers explicitly drew a distinction between observation and experiment.[18]

Second, very few natural philosophers of the seventeenth and eighteenth centuries went to any effort to formulate a philosophy of experiment. In most quarters, the notion was taken to be straightforward and unproblematic. The exceptions here are Boyle and Hooke in England who, as we saw above (Section 3.3), both formulated a relatively sophisticated philosophy of experiment. In the eighteenth century, there continued to be a dearth of serious attempts to develop a philosophy of experiment. Important exceptions, though, are Deslandes' 'Discours' and Jean Senebier's *L'Art d'observer* of 1775.[19] The salient point here, however, is that it would be very surprising, in the light of the lack of serious philosophical reflection on the nature of experiment by natural philosophers, that we would find a worked-out philosophy of experiment amongst eighteenth-century moral philosophers. Perhaps the closest that any moral philosopher came to this is Hume's reflections on the use of experiments in the study of human nature in the *Treatise*, and it is worth digressing briefly to examine this.

6.5 Hume's Philosophy of Experiment

Through an examination of the scattered comments on experiment and observation in the *Treatise* we are able to reconstruct the rudiments of Hume's philosophy of experiment as it pertains to moral philosophy.[20] We do not presume to offer here an exhaustive treatment but merely a sketch of his view that will indicate the scope and limits of experiment in eighteenth-century moral philosophy more generally. We begin with the Introduction of the *Treatise*.

In his Introduction, Hume acquiesces in the standard theory of knowledge acquisition from the period, in which a science is founded upon a set of principles. This provides the starting point for his conception of the role of experiment in moral philosophy. The problem is the epistemic status of and epistemic access to these principles. Hume claims that, like the vulgar, when we consider the principles of the science of man 'we can give no reason for our most general and most refin'd principles, beside our experience of their reality' (*Treatise*, p. 5). Most people are content with this and, adding the standard anti-speculative flourish, 'may derive a more delicate satisfaction from . . . his prudence in avoiding that error, into which so many have fallen, of imposing

[18] See, for example, Cumberland 2005, p. 309.

[19] Materials for a philosophy of experiment can be found in Diderot's *Pensées*, for example, Articles XLII–XLVII; see Diderot 1999, pp. 60–3.

[20] For Hume's early exposure to experimental philosophy at the University of Edinburgh, see Barfoot 1990.

their conjectures and hypotheses on the world for the most certain principles' (*Treatise*, p. 5).

If the lack of certainty of the principles of the science of man is considered a defect, Hume claims, then the same applies to the principles of 'all the sciences, and all the arts'. 'None of them can go beyond experience, or establish any principles which are not founded on that authority' (*Treatise*, p. 6). However, Hume admits that relative to the other sciences, 'moral philosophy has, indeed, this peculiar disadvantage, which is not found in natural [philosophy], that in collecting its experiments, it cannot make them purposely, with premeditation, and after such a manner as to satisfy itself concerning every particular difficulty which may arise'. In contrast to experiments in natural philosophy where one can vary the experimental set up and conditions, in moral philosophy, 'shou'd I endeavour to clear up after the same manner any doubt in moral philosophy, by placing myself in the same case with that which I consider, 'tis evident this reflection and premeditation wou'd so disturb the operation of my natural principles, as must render it impossible to form any just conclusion from the phænomenon' (*Treatise*, p. 6). The lesson is that we must collect up experiments through cautious observation of the different circumstances of human life, examining men 'in company, in affairs, and in their pleasures' (*Treatise*, p. 6). The collecting and comparing of such experiments will lead to a science of man that is no less certain than the other sciences.

Four points are worthy of note here. First, Hume is committed to the two-step model of knowledge acquisition as propounded by experimental philosophers: establish the experimental and observational base, and then develop the science. Second, Hume is clearly using the term 'experiment' as a synonym for 'observation'. Third, he highlights an important constraint on experiments in the science of man, and this is that premeditation and intentionally placing the person in a particular situation so as to observe them would undermine or corrupt the observational evidence by disturbing 'the operation of my natural principles'. Fourth, the use of the first-person pronoun here reveals that Hume also has introspection in mind: he is observing his own self. We ought though to note that, as the *Treatise* deploys the experimental method, some of the experiments mentioned are of third parties and not of the operations of Hume's own understanding.

Let us now proceed to some examples from the body of the *Treatise* to see this methodology in action. In keeping with the standard theory of knowledge acquisition, Hume begins by setting out his principles of human nature. One of these is the principle of the association of ideas. Here is how he applies his adapted experimental method. First, in order to add an element of persuasiveness or credibility by analogy, he likens the principle of the association of ideas with principle of gravitational attraction in natural philosophy:

> Here is a kind of ATTRACTION, which in the mental world will be found to have as extraordinary effects as in the natural, and to show itself in as many and as various forms. Its effects are every where conspicuous; but as

> to its causes, they are mostly unknown, and must be resolv'd into *original* qualities of human nature, which I pretend not to explain. Nothing is more requisite for a true philosopher, than to restrain the intemperate desire of searching into causes; and, having establish'd any doctrine upon a sufficient number of experiments, rest contented with that, when he sees a further examination wou'd lead him into obscure and uncertain speculations. In that case his enquiry wou'd be much better employ'd in examining the effects than the causes of his principle. (*Treatise*, p. 14)

Note the parallel with gravitational attraction and the methodological flourish concerning the need to establish the doctrine upon a 'sufficient number of experiments' and to avoid the search for causes which will lead to 'obscure and uncertain speculations'. The rhetoric of experimental philosophy is doing the lion's share of the work here, for he has not supplied us with 'sufficient number of experiments' in this section. However, it is not long before Hume does furnish us with some concrete experiments.

In *Treatise* 1.3.8 on the causes of belief, Hume enunciates the principle underlying his account of belief formation, namely, that impressions communicate to their related ideas a force and vivacity. After elaborating on the principle for a paragraph, he adduces some experimental evidence for it:

> I must confess I place my chief confidence in experience to prove so material a principle. We may, therefore, observe, as the first experiment to our present purpose, that upon the appearance of the picture of an absent friend, our idea of him is evidently enliven'd by the *resemblance*, and that every passion, which that idea occasions, whether of joy or sorrow, acquires new force and vigour. (*Treatise*, p. 69)

Later in the same section, when Hume is justifying his account of belief formation as involving only an impression, an idea, and a relation of association, he moves into experimental mode: 'In order to put this whole affair in a fuller light, let us consider it as a question in natural philosophy, which we must determine by experience and observation' (*Treatise*, p. 71). He then goes on to adduce some observational evidence. We truncate the passage here in order to capture the accumulation of observational evidence:

> *First* then I observe, that the present impression has not this effect by its own proper power and efficacy . . . I find, that an impression, from which, on its first appearance, I can draw no conclusion, may afterwards become the foundation of belief, when I have had experience of its usual consequences. . . . This is confirm'd by such a multitude of experiments, that it admits not of the smallest doubt.
>
> From a *second* observation I conclude, that the belief, which attends the present impression, and is produc'd by a number of past impressions and conjunctions; that this belief, I say, arises immediately, without any new

> operation of the reason or imagination. Of this I can be certain, because I never am conscious of any such operation . . .
>
> Being fully satisfy'd on this head, I make a *third* set of experiments, in order to know, whether any thing be requisite, beside the customary transition, towards the production of this phænomenon of belief. I therefore change the first impression into an idea; and observe, that tho the customary transition to the correlative idea still remains, yet there is in reality no belief nor perswasion. A present impression, then, is absolutely requisite to this whole operation; and when after this I compare an impression with an idea, and find that their only difference consists in their different degrees of force and vivacity, I conclude upon the whole, that belief is a more vivid and intense conception of an idea, proceeding from its relation to a present impression. (*Treatise*, 1, pp. 71–2)

Our concern here is not with the philosophical content of the claims but the supposed experimental reasoning. Note the transition from 'observe' to 'observation' and then to 'experiments'. Note that all of the 'experiments' are cases of introspection: 'I find, that my impression', 'I change the first impression', 'I compare an impression'. Note too the amplification of the evidential claims: 'confirm'd by such a multitude of experiments', 'a *third* set of experiments'. The same holds for the earlier experiment with the ideational impact of the picture that is a likeness of a friend.[21] This is what Hume equates with natural philosophical enquiry. Yet it is a far cry from a genuine experimental program in natural philosophy, such as James Bradley's work that led him to the discovery of nutation of the Earth's axis, which was being carried out while Hume was composing the *Treatise*.[22]

What are we to make of this? Hume seems to have imbibed the methodology of experimental philosophy and ably deployed its rhetoric, but he cannot be said to have genuinely performed experiments, at least experiments understood as directed and controlled interventions into nature with a view to acquiring knowledge. His principles are propositions about the acquisition of ideas and belief formation and the passions, and they have no normative content. They are the foundations in the moral sciences upon which his moral philosophy will be built. It is worth repeating, therefore, that the term 'experiment' only appears once in Book Three, *Of Morals*.

One could trawl through other eighteenth-century moral philosophers looking for adumbrations of a philosophy of experiment in morals and examining the types of experiment appealed to, yet we contend that there is little that adds to the picture we glean from Hume. There is, however, another form of observation that was central to seventeenth-century experimental

[21] Similar experiments are related in *Treatise* 2.2.2 in the part on 'Of love and hatred'. The section is entitled 'Experiments to confirm this system'; see *Treatise*, pp. 216–25.

[22] See Bradley 1748.

philosophy and which was appropriated by some moral philosophers of the eighteenth century. This is natural history.

6.6 Observation, Experiment, and Natural History

In Chapter 3, we established that from the early 1660s in England many experimental philosophers who endorsed the two-step model, whereby one first accumulates an evidential base and then proceeds to theorising, believed that the most efficacious method for gathering facts was the Baconian method of natural history. The project of Baconian natural history was vast, and, while it was largely eclipsed in natural philosophy with the advent of the new mathematical experimental natural philosophy of Newton, its impact is evident in a number of moral philosophers of the eighteenth century, including Butler, Hume, and Reid.[23]

Perhaps the most important example of the appropriation of the Baconian method of natural history, however, is Adam Ferguson's *Institutes of Moral Philosophy* of 1769.[24] This student manual covers the foundations of moral philosophy, set out in terms of a natural history of man and then a theory of the mind, an account of the nature and attributes of God, an account of moral laws, jurisprudence, casuistry, and politics. As such it is a comprehensive primer for the teaching of moral philosophy.

Our interest is in the philosophical preliminaries and in the first part, which is entitled 'The natural history of man'. Before examining the natural historical content, it is worth noting that throughout Ferguson provides recommendations for further reading as he introduces new section heads, the first of which is Francis Bacon's *Novum organum*, which is the *locus classicus* for his theory of natural history.[25]

Ferguson opens his *Institutes* with some basic concepts. Knowledge is divided into particular facts or general rules with the former preceding the latter (Ferguson 1769, p. 1). General rules arise from speculation and regulate our conduct (p. 2). A collection of facts is a history, whereas rules which explain particulars constitute a science (p. 3). After describing the methods of analysis and synthesis, he turns to laws. A rule deriving from a collection of facts is a law of nature (p. 3). Laws of nature are either physical or moral (p. 4). He then defines moral law: 'A moral law is any general expression of what is good; and therefore fit to determine the choice of intelligent beings . . . A moral law exists in being obligatory' (p. 5). They derive from 'the sentiments and

[23] For Hume and Reid and natural history, see P. B. Wood 1994.

[24] For George Turnbull's conception of natural history's role in moral philosophy, see Turnbull 2005, p. 53 and for his natural historical approach to education and painting, see Gómez 2012a, chapters 4 and 5.

[25] Ferguson 1769, p. 1.

actions of intelligent natures' (p. 6). Physical laws are used for theory, whereas moral laws are used for moral philosophy.

Ferguson then turns to theory. After comparing Newton's account of planetary motions with Descartes' failed vortex theory, a standard trope of experimental philosophers, he introduces natural history: 'All phenomena not comprehended under any known law, are the proper materials of natural history' (Ferguson 1769, p. 8). From theory, we move to moral philosophy. This is defined as 'the knowledge of what ought to be, or the application of rules that ought to determine the choice of voluntary agents' (p. 9). Before we can discover these rules, however, we need to undertake a natural history of man, the centrepiece of which is 'Pneumatics, or the physical history of the mind' (p. 10). It is only natural, therefore, that the first part of the *Institutes* be entitled 'The natural history of Man', and the recommended reading is Buffon's *Natural History*, which we have argued in Chapter 5 is in large part inspired by the Baconian method of natural history and is a kind of revival of the approach to experimental natural philosophy that flagged in Britain with the advent of Newtonianism.

The constituents of the natural history of man are as follows:

1. The form and aspect of man
2. His residence, and manner of subsistence
3. The varieties of his race
4. The period of his life
5. His disposition to society
6. Population, or the generations and numbers of mankind
7. Varieties of choice and pursuit
8. Arts and commerce
9. Disparities of rank and estimation
10. Political establishments
11. Language and literature. (Ferguson 1769, pp. 13–14)

These titles overlap with many of Buffon's topics in volumes I and II of his *Natural History*.[26] They confirm that this sort of natural history is not classificatory but Baconian: it is a natural history of man in the spirit of experimental natural philosophy inspired by Bacon and revived by Buffon.[27] Furthermore, it is clear that the observational base for moral philosophy is to derive from such a history. Only once we have constructed this history can we possibly proceed to the derivation of laws and to moral philosophy proper.

More could be said about this very interesting appropriation of natural history from experimental philosophy; however, it is time to turn to another

[26] See Buffon 1749–89, vols. I and II.

[27] Another Buffon-inspired natural historical approach to moral philosophy is volume 4 of Lord Kames' *Sketches of the History of Man*, H. Home 1774–5, vol. 4.

better-known link between natural and moral philosophy in the early modern period, the notion of laws of nature.

6.7 Moral Philosophy and the Laws of Nature

The juxtaposing of physical laws with moral laws, so evident in the passages from Ferguson's *Institutes*, leads us to consider the close relation between physical and moral laws that is found across a broad range of moral philosophers from the late seventeenth century to the end of the eighteenth century and beyond. This is, in fact, the most obvious and widely cited point of intersection between early modern experimental natural philosophy and the moral philosophy of the period. By the mid-eighteenth century, the drawing of some connection between natural and moral laws was a commonplace. How and why did this come about? In this section, we attempt to reconstruct the history of this development by focusing on just three dimensions of the appropriation of the concept of laws of nature, namely, the role of natural religion, the influence of natural law theory, and the transition from laws to principles. Again, the treatment is selective rather than exhaustive.

A convenient place to start in order to illustrate the appropriation of the notion of laws of nature from natural philosophy by early modern moral philosophers is with Bishop Butler's *Analogy of Religion*, the full title of which sets the agenda: *The Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature*. Ostensibly, Butler was concerned with the analogy between the course of nature and not morality, but religion, both natural and revealed. However, when we turn to the content of the book, we find that it is the analogy between the laws of the natural world and the moral world that is his concern:

> Let us then, instead of that idle and not very innocent Employment of forming imaginary Models of a World, and Schemes of governing it, turn our Thoughts to what we experience to be the Conduct of Nature with respect to intelligent Creatures; which may be resolved into general Laws or Rules of Administration, in the same Way as many of the Laws of Nature respecting inanimate Matter may be collected from Experiments. And let us compare the known Constitution and Course of Things, with what is said to be the moral System of Nature. (Butler 1736, p. xii)

In addition to the anti-speculative sentiment and the reference to experiments, both evidence of the impact of experimental philosophy on his project, this passage includes a clear statement of the salient analogy alluded to in the book's title, namely, that between natural and moral laws. What then is the explanation of the presence of 'Religion, Natural and Revealed' in the title of the *Analogy*?

Our answer to this question begins about sixty years earlier with John Wilkins' posthumous *Principles and Duties of Natural Religion* of 1675. A distinction between natural and revealed religion emerged in the mid-seventeenth century.[28] Natural religion was taken to be a set of principles about the nature and existence of God derived from knowledge of nature. The claim that there are principles of natural religion was first developed in English-language publications in Wilkins' *Principles and Duties of Natural Religion*. He first establishes the principles of natural religion that are then used as the grounds for the duties of natural religion. It is a broadly deontological ethics with a theistic base. Wilkins' work is roughly contemporaneous with Cumberland's natural law theory, which plays upon the unity of natural and moral laws, though Wilkins' book is about natural religion and not the law of nature.

Many philosophers and theologians embraced the project of natural religion in the final quarter of the seventeenth century, including John Tillotson, Robert Boyle, and Edward Stillingfleet. A decisive shift came, however, with the publication of George Cheyne's *Philosophical Principles of Natural Religion* in 1705. Cheyne argued that the principles of natural religion were not merely casually inferred from our knowledge of nature but were the conclusions of demonstrative proofs which had as their premises the laws of nature, that is, Newton's laws of motion and gravitational attraction. The philosophical principles of natural religion, for Cheyne, were natural philosophical principles or laws of nature discovered by experimental philosophers such as Newton. As we saw in Chapter 4, Cheyne's argument strategy was picked up, first in the Netherlands by Lambert Ten Kate and Bernard Nieuwentijt[29] and later by Samuel Clarke and William Whiston. Whiston's *Astronomical Principles of Religion, Natural and Revealed* of 1717 is the high-water mark of this approach that grafts experimental philosophy onto natural religion. But there were many other works that aspired to the same aim. A good example is the Leibniz–Clarke correspondence, which was published in the same year as Whiston's *Astronomical Principles*, for there Clarke tells us in his dedicatory epistle to Princess Caroline:

> the Foundations of *Natural Religion* had never been so deeply and so firmly laid, as in the Mathematical and Experimental Philosophy of That Great Man [Sir Isaac Newton]. . . . *Christianity* presupposes the Truth of *Natural Religion*. Whatsoever subverts Natural Religion, does consequently much more subvert Christianity; and whatsoever tends to confirm Natural Religion, is proportionably of Service to the True Interest of the

[28] In English-language publications, it first appeared in Richard Baxter's *The Reasons of the Christian Religion*, Baxter 1667.

[29] See Ten Kate 1716 and Nieuwentijt 1715, and the English translation introduced by the experimental philosopher John Theophilus Desaguliers, Nieuwentijt 1718.

> Christian. Natural Philosophy therefore, so far as it affects Religion, by determining Questions concerning *Liberty* and *Fate*, concerning the *Extent* of the *Powers of Matter and Motion*, and the *Proofs from Phenomena* of *God's Continual Government of the World*; is of very Great Importance. 'Tis of Singular Use, rightly to understand, and carefully to distinguish from Hypotheses or mere Suppositions, the True and Certain Consequences of Experimental and Mathematical Philosophy.
>
> (S. Clarke 1717, pp. v–vii)

Here, we have all but one of the ingredients that lead us to the genre of Butler's *Analogy of Religion*. We have the foundational role of experimental natural philosophy for natural religion, the link between natural religion and Christianity, and the link between natural religion and 'Questions concerning *Liberty* and *Fate*', that is, moral philosophy.[30] Wilkins' principles of natural religion, which were the basis of the duties of natural religion, now had a deeper foundation in the laws of nature discovered by experimental philosophers. This seems sufficient to explain the tight nexus between experimental philosophy, and in particular its laws of nature, and the grounds of obligation that we find in Butler. It does not explain, however, the positing of a close relation between natural laws and moral laws. For that we need to turn to natural law theory.

It appears that the first philosopher to deploy the notion of physical laws of nature in moral philosophy was the natural law theorist Richard Cumberland in his *De legibus naturae* of 1672,[31] though the thought that there was a seamless transition from *laws* of nature to the *law* of nature is found in the writings of natural law theorists before Cumberland.[32] Let us first set out just how Cumberland conceives of the relation between natural philosophy and moral philosophy before turning to his conception of laws.

For Cumberland, moral philosophy is ultimately founded upon natural philosophy in so far as natural philosophy has some kind of epistemic priority over moral theorising: 'the Whole of *moral Philosophy*, and of the Laws of Nature, is ultimately resolv'd into *natural Observations* known by the Experience of all Men, or into Conclusions of true *Natural Philosophy*

[30] One might suspect that Clarke's Boyle Lectures of 1704 (S. Clarke 1705) and 1705 (S. Clarke 1706) were exemplars of this blending of natural religion, experimental natural philosophy, and moral philosophy, especially when we consider the title of the 1711 composite edition of the lectures, *A Discourse Concerning the Being and Attributes of God, The Obligations of Natural Religion, and the Truth and Certainty of the Christian Revelation*. However, the natural philosophical content of these lectures is surprisingly thin, and it is clear that Clarke only came to grasp the project of natural religion and its relation to experimental philosophy after the 1705 lectures: the term 'natural religion' is absent from the first lectures and experimental philosophy is treated in a rather offhand manner.

[31] See Parkin 1999, chapter 6.

[32] See, for example, Locke's *Essays on the Law of Nature*, Locke 1954, p. 109.

(Cumberland 2005, p. 291).[33] By 'resolv'd into', Cumberland means inferred from, for this is how he puts it in the introduction, expressing his aim 'to deliver the Precepts of moral Philosophy, and to deduce them from some little Knowledge of Nature presuppos'd' (Cumberland 2005, p. 254). At first sight, this appears to be a thoroughly naturalistic approach to moral philosophy, and, moreover, Cumberland occasionally refers to recent developments in experimental philosophy, including the work of Boyle, Christopher Wren, and others.[34] The association of his natural law theory with experimental philosophy is further embellished by the presence in the posthumous Towers edition of 1750 of extracts from Newton's 'General Scholium' and Queries to the *Opticks* which set out the method of experimental philosophy.[35] However, closer scrutiny of Cumberland's text reveals a less radical position.

First, Cumberland is working with a broad conception of natural philosophy that includes God and immaterial souls, a conception that can hardly be called naturalistic.[36] Second, he takes it as foundational that God is the first cause of all motion and therefore all material effects in nature. Third, when he speaks of the principles of natural philosophy, he is not conceiving of, say, inductive generalisations that result from experiment and observation, for he acquiesces in Cartesian speculative natural philosophy, including the view that the essential nature of matter is extension,[37] one of the very doctrines that was seriously challenged by Boyle's pneumatic experiments in the 1660s. And, moreover, he is fully cognisant of the fact that some may disagree with these natural philosophical principles.[38] Most importantly, however, while Cumberland mentions the mechanical philosophy and alludes to Descartes' conservation law,[39] it is not evident that he even has a clear conception of just what a law of nature is. For if we examine the examples he furnishes us with, we find that he never speaks of laws that involve determinate quantitative relations, such as Snel's Law of Refraction. Instead, he refers in the most general way to those who were working on laws of motion, such as Galileo, and those working on the laws of impact at the end of the 1660s,[40] or his references take the form of

[33] See Cumberland 1672, p. 3: 'Totam Moralis Philosophiæ, Legumque Naturalium Doctrinam in observationes Naturales omnium Experientia notas, aut in Conclusiones a vera Physiologia agnitas, & stabilitas ultimo resolvi'.

[34] See, for example, Cumberland 2005, pp. 302, 565–6.

[35] See Cumberland 2005, pp. 874–5.

[36] Cumberland 2005, p. 291. See the parallel in Locke's *Essay* IV. xxi. 2.

[37] Cumberland 2005, p. 332. For his apparent acquiescence in the Cartesian vortex theory, see p. 331.

[38] Cumberland 2005, p. 309.

[39] Cumberland 2005, pp. 332 and 397–8.

[40] The reference to John Wallis, Christopher Wren, and Christiaan Huygens (Cumberland 2005, p. 332) is almost certainly to a set of papers that appeared in the *Philosophical Transactions* in the late 1660s. See Murray, Harper, and Wilson 2011.

the pre-Cartesian notion of generalisations about how nature acts or nature's customary behaviour. For example:

> Nor do we with *greater difficulty learn* from Experience the Truth of these *Propositions*, 'That it is necessary to the Common Good, that a distribution of Things and mutual Services should be made'; and, 'That it should be preserved, by acting, both with respect to Others and Ourselves, as the Preservation of Nations, single States and Families, whereof we are Part, requires': (From which all the Laws of Nature, and the Virtues proceed:) *Than we learn*, 'That it is necessary to the Life and Health of an Animated Body, that Nourishment should be communicated to all its Parts, and that the Distribution made by Nature should be preserv'd by every Member so discharging its proper Office; that first the principal Parts, then the less Principal, and the Meanest, may have their Obstructions remov'd, their Decays repair'd, and their Growth continued, 'till they arrive at the Stature and Strength prescrib'd by Nature'.
>
> The truth in *both Cases* is *resolv'd* into these, or such like, *Propositions*; 'That those Things which preserve the Whole, preserve all its Parts'; and 'That the Preservation of the less Principal or subordinate Parts, proceeds from the Preservation of the Principal'; which, because they are *evident* from the *Definitions* of such Causes, may justly be said to be discover'd by the *Nature of Things* to our *Experience*. *For*, 'Definitions are learn'd from our Experimental Knowledge of the Nature of Things'. Farther; *as* the whole *Certainty* of the rules of *Medicine* and *Diet* proceeds from the *unchangeable* Efficacy of such corporeal Causes to produce their Effects in an Animate Body; *in like manner* all *Certainty* of those practical Propositions, which are Laws of Nature, and which compose *Moral Philosophy*, and determine the Nature of all the Virtues, proceeds from the *unchangeable* Influence of Human Actions.
>
> (Cumberland 2005, pp. 702–3)

It seems most likely, therefore, that the close association that Cumberland draws between physical and moral laws derives from a largely pre-Cartesian conception of laws and not from a deep familiarity with the nature and function of determinate laws of nature in the new sense first set out by Descartes and subsequently widely adopted by natural philosophers, such as Huygens, Wren, and Wallis, and later by those promoting natural religion, such as Cheyne and Whiston.

Nevertheless, it is but a small step to move from the juxtaposing of moral and natural philosophy and their laws in Cumberland to a more up-to-date appropriation of the new laws of nature as an analogue of moral laws. One of the earliest to move in this direction was Francis Hutcheson, who, in his *Essay on the Nature and Conduct of the Passions and Affections* of 1728, speaks of his definitions in moral philosophy functioning as axioms 'with Analogy to the

Laws of Motion' (Hutcheson 1728, p. 34).[41] Hutcheson has in mind definitions such as 'Natural *Good* is Pleasure: *Natural Evil* is Pain' (p. 34). This is not yet to posit an equivalence between moral and physical laws, but to point to the foundational role that both definitions and laws of motion play in demonstrative reasoning in their respective subjects.

Thus, we can see a transition from regarding moral laws as founded on the customary behaviour of nature in Cumberland to the analogous epistemic role of laws and definitions in moral and natural philosophy in Hutcheson and the general claim that the laws of motion are analogous to moral laws in Butler. The high-water mark of the aligning of physical laws with moral laws in English-language philosophy[42] is found in the writings of the Scots moral philosopher and teacher of Thomas Reid, George Turnbull.[43] Let us examine his view, though again it must be stressed that only a summary account can be presented here.

Turnbull begins by distinguishing natural and moral philosophy: the former pertains to the world as perceived by the senses and the latter to that which is perceived by the inner sense, the inward operations of the mind. Both sciences 'must set out from the same first principles, and be carried on in the same method of investigation' (Turnbull 2005, p. 47). More specifically, natural philosophy is defined as the study of the general laws in the sensible world which produce 'beauty, order, and good' (p. 47).

He then states three principles for these sciences. First, without general laws there would be no order and therefore no science. Second, general laws operate throughout the whole of nature. Third, general laws are good laws 'which by their steady and uniform prevalency produce its good, beauty, and perfection in the whole' (Turnbull 2005, p. 50). Thus, Turnbull builds a normative claim into his conception of the operations of general laws. So, for example, a corollary of the third principle is that no evil effects can follow from the operation of a general law. Thus, 'no effect, for example, of gravitation can be evil, if gravitation be a good general law' (Turnbull 2005, p. 51). Moreover, all natural phenomena can be explained as the effects of the operation of general laws.

Interestingly, for Turnbull, this implies that 'when natural philosophy is carried so far as to reduce phenomena to good general laws, it becomes moral

[41] Poovey implies that Hutcheson was the first to deploy the natural philosophical notion of laws of nature in moral philosophy. See Poovey 1998, pp. 183–4.

[42] For the alignment of moral laws with physical laws in French philosophy, see especially Montesquieu's *The Spirit of the Laws* (Montesquieu 1989) and for commentary Klosko 1980.

[43] The American theologian Jonathan Edwards was right to claim that 'Dr. *Turnbull*, . . . greatly insists upon it, that the experimental Method of Reasoning ought to be gone into in moral Matters, and Things pertaining to the human Nature; and should chiefly be relied upon, in moral, as well as natural Philosophy', Edwards 1758, p. 74.

philosophy' (Turnbull 2005, p. 53). If it fails to do this, 'it hardly deserves the name of philosophy in the sense of *Socrates, Plato*, Lord *Verulam*, *Boyle*, *Newton*, and the other best moral or natural philosophers' (p. 53). The three principles mentioned above pertain equally to moral philosophy, such that there are general laws which give rise to all the phenomena of the human mind, 'its powers, faculties, dispositions and affections'. Thus, according to Turnbull, not only should all natural philosophy be viewed as a form of moral philosophy, all moral philosophy is just a species of natural philosophy! It remains then to discover just what the general laws of the human mind are. And this is done using the same methods as in experimental natural philosophy.[44] The method that he advocates is quite similar to that of Hume in the *Treatise*. It is salutary to note, therefore, that one of the more important laws of moral philosophy proposed by Turnbull is the law of association of ideas which, just like Hume's principle of association in *Treatise* 1.1.5, published at virtually the same time, is described as a form of cohesion (Turnbull 2005, pp. 119, 123, 129; *Treatise*, p. 14).

Finally, we turn to Thomas Reid's conception of the relation between moral laws and the laws of nature. He regards the salient equivalence to be in their range of applications:

> [Moral laws] may, in this respect, be compared to the laws of motion in the natural world, which, though few and simple, serve to regulate an infinite variety of operations throughout the universe.
>
> And as the beauty of the laws of motion is displayed in the most striking manner, when we trace them through all the variety of their effects; so the divine beauty and sanctity of the principles of morals, appear most august when we take a comprehensive view of their application to every condition and relation, and to every transaction of human society.
>
> (Reid 2010, p. 281)

To sum up, it is clear from the foregoing that different philosophers expressed the relation between natural and moral laws in different ways. For some, such as Bishop Butler, moral laws are merely analogous to natural laws; for Hutcheson, moral laws function like the axioms of natural philosophy. For Turnbull, however, they are cut from the same cloth: moral laws are not merely analogous to natural laws but are different species of the very same genus. And for Reid, moral laws are like the laws of motion insofar as they have countless applications.

6.8 Conclusion

In conclusion, we ought to ask whether the ESD, the appropriation of the anti-speculative stance, the appeals to experiment and observation and to laws of nature were merely window-dressing, or whether they brought about

[44] See Turnbull 2005, pp. 19–20, quoted above on pp. 183–4.

substantial changes within moral philosophy. Would eighteenth-century moral philosophy have been different in the absence of the impact of experimental philosophy?

It would be premature to draw any definite conclusions before all the evidence is in. However, three pointers are worthy of consideration by way of conclusion. First, the theory of principles that undergirded so much reflection on the nature of knowledge, both natural and moral, was significantly altered by the appearance of laws of nature. This reflected the shift in natural philosophy from principles that satisfied very stringent requirements, say, that they be universal, essential, and convertible, to laws of nature as principles that were experimentally established. And it does seem that in the moral philosophy of the long eighteenth century, this is reflected in the general shift from necessary moral principles that have normative content – such as the Golden Rule – to contingent principles concerning human nature. This would not have occurred without the dramatic changes in natural philosophy that were attributed at the time to experimental philosophy.

Second, and with an eye to contemporary x-phi, the eighteenth century remained a period in which the study of the human mind and behaviour was what we might call a proto-psychology, transitioning from a speculative, even metaphysical, science to a practical or empirical one. That moral philosophy was caught up in this period of transition is as much the outcome of traditional disciplinary boundaries as it was an expectation that the fruits of experimental philosophy knew no limits and were available to all.

Third, and finally, it could hardly have escaped notice that no mention has been made here of the role of mathematics in experimental philosophy and its impact on the moral philosophy of the late seventeenth and eighteenth century. Hume's second *Enquiry*, for example, makes use of the analogy between mathematical and moral reasoning to great effect.[45] Yet there is a tension that pertains to the application of mathematics to moral philosophy that is not present in the types of impact that we have surveyed. For, on the one hand, mathematical reasoning was unquestionably essential for the type of experimental natural philosophy developed by Newton, and on the other hand, Euclidean geometry provided the kind of exemplar of a demonstrative science or *scientia* that provided the model for the speculative sciences. Thus, when Locke claims in the *Essay* that morality might become a demonstrative science like mathematics, he is implicitly contrasting it with natural philosophy. His conception of moral philosophy is as a science that is able to be demonstrated from true and certain principles, and in this he was followed by others in the

[45] See Hume 1998, pp. 85–7. For Hutcheson's appeals to mathematics in his *An Inquiry into the Original of our Ideas of Beauty and Virtue* (2004), see Poovey 1998, pp. 185–91.

eighteenth century.[46] So, the theme of mathematics as a component of experimental philosophy can be seen to have an ambiguous status, and a thorough treatment of its role in early modern moral philosophy is beyond the scope of this chapter. It is enough to have established here that there were at least four points of impact of experimental natural philosophy on early modern moral philosophy. The hope is that further research will provide us with a more comprehensive and nuanced understanding of the application of experimental methods to moral subjects.

[46] See Locke, *Essay* IV. iv. 7. Proponents of this view include James Tyrrell (1692) and Jean Barbeyrac (1729). While Locke's advocacy of the view was the starting point for a host of eighteenth-century treatments of this issue, it is found in many philosophers before Locke, including Samuel Pufendorf (1660 and 1672), Baruch Spinoza, Benjamin Whichcote, and Henry More. For further discussion, see Parkin 1999, pp. 175–8 and van Bunge 2011.

PART III

From Experimental Philosophy to Empiricism

CHAPTER 7

Experimental Philosophy in Eighteenth-Century Germany

The foregoing chapters have documented the wide-ranging influence of experimental philosophy on natural philosophy, medicine, and ethics. In the light of this, it is striking that, nowadays, the existence of early modern experimental philosophy is only known by specialists, and it is mentioned rarely, if at all, in histories of philosophy. The dynamics whereby experimental philosophy ceased to be a recognisable, influential philosophical movement varied to some extent from country to country. In the third part of this volume, we trace how these dynamics unfolded within a specific cultural context, that of eighteenth- and early nineteenth-century Germany.

We argue that, while experimental philosophy was well known and influential in Germany in both the early and late eighteenth century, a decisive shift took place at the turn of the nineteenth century. As Kantian and post-Kantian philosophies rose in popularity, a priori methods found widespread acceptance, and experimental philosophy fell quickly out of fashion. At the same time, Kant and his disciples introduced the dichotomy of empiricism and rationalism, which soon became common philosophical currency and provided the basis for a comprehensive account of the history of early modern philosophy (what we call below 'the standard narrative'). Around the first decade of the nineteenth century, the early Kantian historians Wilhelm Gottlieb Tennemann and Johann Gottlieb Buhle articulate the first comprehensive accounts of early modern thought which revolve around the development of empiricism and rationalism – the first accounts which are strikingly similar to the standard narrative. While the historiographical notions of empiricism and rationalism were becoming popular, the dichotomy of experimental and speculative philosophy lost currency, and experimental philosophy itself ceased to be recognised as a distinctive early modern philosophical movement.

This chapter documents the widespread influence of experimental philosophy in eighteenth-century Germany. Sections 7.1 to 7.4 focus on the first half of the century, specifically on Christian Wolff and the Berlin Academy. We first argue that Wolff, the most influential German philosopher of the period, engaged at length with the methodological views of experimental philosophers and relied extensively on experience as the foundation of his own philosophy.

However, his focus on developing a comprehensively deductive philosophical system ultimately overshadowed his commitment to basing philosophy on experiments and observations. We then show how the pair of experimental and speculative philosophy became enshrined in the structure of the Berlin Academy as a result of Maupertuis' rebranding of its four disciplinary classes in 1746. In Sections 7.5 to 7.7, we turn to the second half of the century. We focus on the uptake of the methodological views of experimental philosophers in the literature on empirical psychology that flourished in the period; the methodological reflections on the relation of experimental and speculative philosophy of Johann Nicolaus Tetens, a proponent of empirical psychology who had a strong influence on Immanuel Kant; and the frequent contrasts between experimental and speculative methods in a range of works published between the 1770s and the end of the century.[1] Our survey of those contrasts shows how, as Kantian and post-Kantian philosophies rose in popularity, a priori reflection gained increasing acceptance and experimental philosophy went out of fashion.

7.1 Wolff: An Experimental Philosopher?

Wolff's philosophy is an ideal case study of the impact of experimental philosophy because of its wide-ranging influence in eighteenth-century Germany. Wolff's philosophy was 'the dominant force in German universities' (Kuehn 1996, p. 254) between 1713 and his death in 1754, and his works on nearly all branches of philosophy were widely read.[2] For instance, fourteen editions of Wolff's *German Logic* were published between 1713 and 1754, at an average of a new edition every three years (Arndt 1962, p. 99). Scores of

[1] While the chapter provides many examples of the uptake of the rhetoric of experimental philosophy in eighteenth-century Germany, this rhetoric was not as widely adopted in Germany as it was in Britain. Many authors who emphasised the importance of experience often used the expressions 'speculation' and 'speculative philosophy' in a neutral or disciplinary sense, rather than as labels of a misguided methodological approach to philosophy. For instance, Marcus Herz's extended paraphrasis of Kant's Inaugural Dissertation, the *Reflections on Speculative Philosophy*, criticises 'useless speculations' (Herz 1990 [1771], pp. 37, 45) but does not draw any explicit, extended contrast between speculations or hypotheses and experience, observations, or experiments. Johann August Eberhard's *General Theory of Thinking and Sensing*, which won the annual essay competition promoted by the Berlin Academy in 1776, states that the distinctive trait of the new *speculative* philosophy is its reliance on experience, more specifically, on observations of the mind (Eberhard 1776, pp. 4–5) and 'on the moral sensations' (p. 9). Along similar lines, Feder (1788, p. 43) calls Reid's *Essays* 'one of the most important products of speculative philosophy' for their careful psychological observations.

[2] Even in a university like Königsberg, where 'Wolffianism was never a dominant movement' (Sgarbi 2010, §4), professors of metaphysics often used textbooks by Wolff and his disciples, such as Friedrich Christian Baumeister. See Sgarbi 2010, §3; Rumore 2007, pp. 19–39.

authors wrote manuals inspired by Wolff's ideas,[3] and even his fiercest opponents, such as Christian Adolf Crusius, were deeply influenced by his views.[4] Thus, any overt influence of the tenets of experimental philosophy on his works resulted in a broad awareness of those tenets among Wolff's peers and successors.

Wolff was well acquainted with the natural philosophical and methodological views of British experimental philosophers. This was not without precedent in Germany. Christoph Sturm had collected many of the more important experiments of the Fellows of the early Royal Society in his *Collegium experimentale sive curiosum* of 1676, in which he presented the 'experimental method' as 'the source and single cause' of the 'most fortunate progress' of seventeenth-century natural philosophy.[5] Wolff's volumes of experimental reports contain scores of references to Boyle's and Hooke's works.[6] Wolff reviewed Locke's works in the *Acta Eruditorum* (Petrocchi 2004, p. 117) and he was familiar with several Lockean doctrines.[7] He made frequent references to Newton's *Principia*[8] and *Opticks*,[9] including the second edition of the *Principia* and the queries in the *Opticks*, where Newton's adherence to the methodological outlook of experimental philosophy is most explicit.[10]

Given Wolff's knowledge of British experimental philosophers, it is not a coincidence that he repeats many of their methodological proclamations. Experimental philosophers claimed that one should not posit natural philosophical principles and proceed solely from them, independently from

[3] The third section of his *Complete Works* (Wolff 1962–), which includes works of eighteenth-century Wolffian philosophers alongside some recent critical studies, includes 150 volumes and counting.

[4] Compare Crusius 1745 with Wolff 1751, and see Kuehn's (1996, p. 255) comments on Crusius. Wolff and the Wolffians influenced, for example, Kant's views on the relation between logic and the human mind (Hinske 1980), the antinomies of the first *Critique* (Hinske 1993), and Kant's notion of representation (Rumore 2007).

[5] Sturm 1676, 'Programma invitatorium'. For the second volume of his *Collegium experimentale*, see Sturm 1685; see also Ahnert 2003. For an association of Sturm and the academy at Altdorf with experimental philosophy, see the review of *Collegium experimentale* in *The Compleat Library*, 1692, 1, pp. 288–90.

[6] Wolff cites, among others, Boyle's *Defence against Linus* (Wolff 1727–9, 1, §124), *Experiments and considerations touching Colours* (§165), *Medicina Hydrostatica* (§187), and *New Experiments Touching the Spring of the Air* (§§63, 86, 133, 135, 182). He also cites Hooke's *Micrographia* (Wolff 1727–9, 2, §133), his *Posthumous Works* (Wolff 1727–9, 2, §§6, 36; 1741, 5, §19; 1751, §84), and the *Philosophical Experiments* edited by Derham in 1726 (Wolff 1727–9, 2, §23).

[7] See Zart 1881, Bissinger 1970, and Poggi 2007.

[8] For example, Wolff 1740a, §161 n.; 1741, 5, §257; 1755, p. 144.

[9] For example, Wolff 1727–9, 2, §§153, 155, 157; 1740a, §20 n.; 1741, 5, §12.

[10] For example, Wolff 1727–9, 2, §§10, 104.

experience. Wolff agrees: 'It seems to me that it is still much too early to posit certain general principles [*Gründe*] as the elements of things, from which one wants to derive everything that is possible in nature by means of the pure intellect as, for instance, *Descartes* did.'[11] Like British experimental philosophers, Wolff holds that Descartes' recourse to a wrong method turned his physics into mere fiction. Descartes 'lapsed into a poetic licence' (1755, p. 143). When one infers prematurely particular natural events and features of natural objects from few general principles, one 'fantasises and starts to poetise'.[12] 'Poetising' and 'developing fictions' were typical expressions with which British philosophers criticised Descartes. Like them, Wolff relates natural philosophical fictions to the use of hypotheses: 'We do not approve the fabricated hypotheses that, nowadays, very many people introduce within natural philosophy. They arbitrarily invent all sorts of things, as if they could in the least prove that what they imagine can exist within nature' (Wolff 1741, 5, §311). Several experimental philosophers declared that, to avoid this mistake, they refrained from formulating hypotheses. Wolff embraces the same policy: 'I considered that I must avoid fictitious hypotheses, of which the writings of physicists abound everywhere' (1735d, p. 179). 'The study of physics would be very useful for the benefit of human life if we were eventually freed from hypotheses . . . and all my efforts tend to that [aim].'[13]

Having ruled out the speculative method that is based on hypotheses and principles, Wolff concurs with experimental philosophers that the study of nature must start from experience, that is, observations and experiments.[14] These must be carried out on the model of Bacon (1755, p. 142), 'the Patriark of Experimental Philosophy'.[15] Wolff also praises Boyle (1755, p. 142) and Newton, the author of the 'incomparable *Mathematical Principles of Natural Philosophy*' (p. 144). Like Newton,[16] Wolff declares: 'Indeed, I do not admit within science any other principles, on the basis of which I give reason of something else, apart from those that were deduced from observations and experiments following a legitimate thread of inference' (1755, p. 143; see 1735d, p. 180).

[11] Wolff 1725, Preface, sig.): (5 3–4; see 1733, §164.
[12] Wolff 1725, Preface, sig.): (5 4.
[13] Wolff 1735d, p. 190. In this regard, it is important to note that Wolff's use of the term 'hypothesis' is more constrained than Boyle's and Locke's use. They often called whole theories, such as Descartes' vortex theory, 'hypotheses'. Wolff occasionally refers to astronomical theories as hypotheses. However, he normally employs this term for specific statements that are assumed to be true because they explain certain phenomena (1740a, §126).
[14] On the distinction between observation and experiment, see Wolff 1738, §456. On the importance of experiments, see 1733, §8.
[15] Power 1664, p. 82; see Voltaire 1994, pp. 51–2.
[16] *Principia*, p. 943; 1715, pp. 222–4.

Natural philosophy as well as philosophy as a whole must derive their principles from experience[17] and never trespass its boundaries: 'I do not proceed beyond what observations and experiments allow; as to the other things, I prefer to acknowledge my ignorance, rather than deceiving myself and others with fictions' (1735d, p. 179). Experiments are especially helpful as they enable us to establish truths that observations alone cannot reveal (1740a, §107). Wolff stresses the importance of providing detailed experimental reports, which will enable others to replicate the experiments.[18] He puts his recommendation into practice in his three volumes of experimental reports.[19]

As we have seen in Part II, in the eighteenth century some philosophers endeavoured to apply the method of experimental natural philosophy to other disciplines, such as the moral sciences. Similarly, Wolff claims that 'experimentation can also be extended to every other [part of] philosophy [beyond natural philosophy], and in this way a broader notion of *experimental philosophy* would emerge than when, as is usually the case, that expression is only used to designate experimental physics' (Wolff 1740a, §107 n.) Wolff emphasises the importance of experiments for moral and political philosophy.[20] He sketches the disciplines of experimental cosmology (1737a, §4), experimental theology,[21] and even experimental ontology (1729c), although he does not develop them in detail.[22] On the whole, Wolff agrees on many points with British experimental philosophers, especially those Newtonians who aimed to 'banish all *hypotheses*'.[23] Yet, as we argue in the next section, Wolff's considered views on hypotheses differ from those of the Newtonians.

7.2 The Role of Hypotheses

Like Newtonian experimental philosophers, Wolff praises experiments and criticises the way many natural philosophers employ hypotheses. Yet Wolff does not oppose every use of hypotheses. In his view, 'philosophy

[17] See, in the first place, Wolff 1740a, §§34, 35, 107, and also 1725, Preface, sig.):(5 3; 1737b, p. 329.

[18] Wolff 1727–9, 1, p. 5; 1733, §164; 1962 [1754], p. 122.

[19] Wolff 1727–9. On Wolff's physiological experiments and observations, see Mühlpfordt 1989.

[20] Wolff 1735a, p. 682; 1740a, §107 n.

[21] Wolff 1729a, p. 137; 1735b, §12; 1740a, §107 n.

[22] See École 1979a; 1979b, pp. 48–52. Wolff categorises economy, politics, technology, and the liberal arts as parts of experimental philosophy in his classification of the branches of knowledge (Tonelli 1975, pp. 244–5).

[23] Toland 1696, p. 15; see Newton 1715, pp. 222–4. This might seem surprising, given that Wolff was traditionally categorised as a rationalist (e.g., Campo 1939, p. 17; Copleston 1960, pp. 105–8; Sassen 2015, §2). However, that categorisation has often been disputed (e.g., École 1978, pp. 425, 428; Arndt 1986; Goubet 2002).

must use hypotheses insofar as they pave the way for the discovery of certain truth' (Wolff 1740a, §127).

Astronomers provide the model for this use of hypotheses:

> From some present events, they infer what they have to assume, in order for [the events] to follow, and they posit ... that the hypothesis applies to all [similar] events ... To determine whether they did well to assume the hypothesis, they infer what follows from it on the basis of a correct reasoning, in order to compare it with the remaining phenomena that they have either observed or that can be inferred from observations. [They do this] to determine whether what has been observed agrees with the hypothesis. If they find that [observations and hypothesis] are in contrast with one another, they improve the hypothesis, and in this way they constantly move closer to the truth. (Wolff 1729b, p. 186; see 1740a, §127 n.)[24]

Natural philosophers should imitate 'astronomers by deriving hypotheses from common observations and by correcting and perfecting them after they have sought [to make new] observations and to examine experiments' (1741, 5, §310). 'And so, in the same way as astronomers, we come closer and closer to the truth, until ... we finally reach it' (1729b, p. 187).

Observations and experiments, then, are not an alternative to the assumption of hypotheses. On the one hand, experiments are necessary 'as examinations of physical hypotheses' (1735d, p. 167; see 1733, §164). They enable us to confirm, refine, or reject them. On the other hand, hypotheses and the theories of which they are part can provide a stimulus to carry out new observations or experiments. 'Based on the example of the astronomer', Wolff stresses

> how much theory owes to observations and how much, on the other hand, observations owe to theory, since observations perfect theory and theory in turn continuously perfects observations. Those who are ignorant of any theory and do not have much ability to use the faculty of knowing will only discover obvious and mostly imprecise [truths] on the basis of observations. There would not be much progress, unless one could presuppose some theory; and the more [a theory] is developed, the more discoveries one will make by means of observation[s].
>
> (Wolff 1735a, p. 688)[25]

Consistent with his emphasis on the interaction of hypotheses and observations, Wolff criticises those who reject every hypothesis in the field of natural philosophy: 'If one rejects the use of hypotheses within philosophy, and only wants to admit what is already certain and established, one will much obstruct the progress of the sciences, which able philosophers should promote as much

[24] This passage employs the expression 'arbitrary proposition' (*willkührlicher Satz*) to designate hypotheses, as can be seen by comparing the text with the Latin version (1729b). On the role of hypotheses in Wolff's philosophy, see Corr 1970, pp. 138–42.

[25] See Cataldi Madonna 2001b, pp. 79–81.

as they can' (Wolff 1737c, p. 243).[26] Many Newtonians fall within the category that Wolff criticises. According to Wolff, those who praise Newton for excluding hypotheses from the domain of natural philosophy do not realise that Newton himself 'indulges in hypotheses in those very areas in which they think he abstained from employing them . . . In fact, what else is universal attraction or gravity, . . . if not a hypothesis that is assumed because of certain phenomena and then is extended to all matter?' (Wolff 1741, 5, §309). Wolff's refrain is that not the use, but the abuse of hypotheses must be condemned.[27] He formulates several prescriptions that philosophers should follow to avoid abusing of hypotheses, for instance:

1. before accepting a hypothesis, one should make sure that it does not entail any contradiction (1741, 5, §311);
2. one must show that the entities whose existence the hypothesis implies exist in nature;[28]
3. if a hypothesis is incompatible with one single observed phenomenon, it must be abandoned (1740b, §609; see 1741, 5, §311);
4. if a hypothesis does not explain all the phenomena that it was designed to explain, it is improbable (1740b, §610);
5. since experiments and observations can make hypotheses more probable, but not certain, one must never mistake hypotheses for certain propositions, which Wolff calls dogmas (1735b, §§78–9). Also, one should not employ hypotheses as premises in the proofs of dogmas, because one cannot establish a certain proposition on the basis of uncertain assumptions (1740a, §128);
6. one must not rely on hypotheses to establish a proposition, if it is possible to prove it in such a way as to make it certain (1737c, pp. 235–6);
7. one must not employ hypotheses as reasons for action where mistakes might bring about dangerous consequences, for instance within medicine and moral philosophy (1737c, pp. 237–9).

This qualified endorsement of hypotheses differentiates Wolff from those philosophers who, like Newton, denied any role for speculative hypotheses within natural philosophy.[29] However, not all experimental philosophers were as radical as Newton in their professed rejection of hypotheses. Some, like Samuel Parker and Thomas Sprat, granted that hypotheses may have a place within natural philosophy, but only in a distant future, after the completion of

[26] See Wolff 1737c, p. 266.
[27] See, for example, Wolff 1729b, p. 181; 1735b, §83; 1740a, §127 n.
[28] Wolff 1737c, pp. 260–1. This requirement does not apply to algebraic and geometrical hypotheses (1741, 5, §257).
[29] For a detailed analysis of the role of hypotheses in Newton's natural philosophy, see K. Walsh 2014, pp. 63–80 and 2017, pp. 204–6.

large natural histories on which they can be based.[30] And even Sprat did not wait until the completion of natural histories to endorse a number of hypotheses, such as the corpuscularian hypothesis (Sprat 1667, pp. 254–6). This suggests that, in their view, we are entitled to endorse some hypotheses before the completion of natural histories. According to Hooke, this was the position of the Royal Society. Hooke writes that the Royal Society rejected not every hypothesis, but 'any *Hypothesis* not sufficiently grounded and confirm'd by *Experiments*' (Hooke 1665, 'To the Royal Society', sig. A4). Along similar lines, Thomas Sydenham proposed that hypotheses based on facts and observations are 'stable and permanent' (1848, 2, p. 173). Wolff would agree.

The endorsement of some natural philosophical hypotheses led Boyle, like Wolff, to formulate a list of the requirements that a hypothesis should satisfy to be 'good' or even 'excellent'.[31] The Newtonian 's Gravesande even spelled out a six-step method for formulating good hypotheses (1737, pp. 301–5). Despite their proclamations against theorising and speculating, Boyle and Hooke admitted that knowing some hypotheses and theories helps researchers in their experiments and observations, 'for by this Means the Mind will be somewhat more ready at guessing at the Solution of many Phenomena almost at first Sight, and thereby be much more prompt at making Queries, and at tracing the Subtlety of Nature, and in discovering and searching into the true Reason of things' (Hooke 1705b, p. 19).[32] In turn, experiments and observations test hypotheses,[33] giving rise to a virtuous interaction of experiment and theory. Thus, Boyle detailed the mutual benefits of experimental and speculative philosophy, including those 'flowing from speculative philosophy to experiments'.[34] Boyle's and Hooke's views are in line with Wolff's comments on 'how much theory owes to observations and how much, on the other hand, observations owe to theory' (Wolff 1735a, p. 688).

In view of these similarities between the views of Boyle, Hooke, and Wolff, it may be tempting to class them all as refined experimentalists. While emphasising the reliance of natural philosophy on experience, refined experimentalists acknowledge the usefulness of hypotheses and the reciprocal relation of experiment and theory. However, there are two differences between Wolff on the one hand and Boyle and Hooke on the other.

First, Boyle highlights the reciprocal relation of experiment and theory while explaining how to construct natural histories.[35] This is the first stage of

[30] See, for example, Parker 1666, pp. 45–6; Sprat 1667, p. 107.
[31] 'MS Notes on a Good and an Excellent Hypothesis', Boyle 1991, p. 119; Boyle; 'The Requisites of a Good Hypothesis', B 13 271–2.
[32] See also *Boyle Corr.*, 3, p. 171; Royal Society Boyle Papers, 9, fol. 30^{v}, transcribed in Sargent 1995, p. 164; Sprat 1667, p. 257. The view derives from Bacon, see SEH 4 358–9.
[33] B 5 305; *Boyle Corr.*, 3, p. 171; 2008 [1666]; Hooke 1705b, p. 19; 1705c, p. 331.
[34] Boyle, 'Materials relating to The Usefulness of Natural Philosophy', B 13 354.
[35] See Anstey 2014a, pp. 117–18.

natural philosophical inquiries. Its aim is not to refine theories or hypotheses, but to collect data in view of the future elaboration of natural philosophical systems. Although Hooke acknowledges the interaction of hypotheses and experiments, he also states that, until a 'Philosophical History' is 'pretty well stored with choice and sound Materials, the Work of raising new Axiomes or Theories is not to be attempted' (Hooke 1705b, p. 18). It is not obvious how Boyle's and Hooke's statements on the reciprocal relation of experiment and theory can be reconciled with their two-stage model of natural philosophical inquiry. This problem does not arise for Wolff because the two-stage model is foreign to his outlook. For Wolff, data collection and theory building are largely simultaneous and interdependent.

Second, Boyle and Hooke hold that our entire natural philosophical knowledge must be acquired a posteriori from the 'materials' of observations and experiments.[36] They would reject any non-empirical principle as an unwarranted speculation. Instead, Wolff holds that a priori propositions are an essential part of natural philosophy. According to Wolff, experiments are also useful to confirm 'what has been proven *a priori*' (1729a, p. 137). For instance, 'what is proven in mixed mathematics by means of mathematical principles can also be taught by means of experiments'.[37] The laws of motion

> are indeed proven in [mixed] mathematics; however, this does not prevent one from explaining them by means of experiments as well. When *Galileo* discovered the rules according to which heavy bodies move when they go upward, they fall or they are thrown, he did not stop at mathematical demonstrations, but he also confirmed them with experiments. The great mathematicians *Huygens* and *Wren*, too, proceeded in the same way . . . They had good reason [to do so]. In fact, experiments are proofs that one sets up in order to get further reassurance that one has not been unlucky in one's reflection. (Wolff 1733, §178)[38]

Hence, for Wolff, natural philosophical knowledge does not derive entirely a posteriori from experiments and observations. Some natural philosophical truths can only be established a posteriori, but others can be proven a priori and confirmed a posteriori.

This integration of a priori and a posteriori truths is reflected in Wolff's views on the relations between the sciences. In his view, experimental physics (*physica experimentalis*) is not the whole of physics. It is only the first part of physics, designed to provide experiments and observations on which

[36] For the metaphor of construction materials, see the last quote and Hooke's comment in Oldroyd 1980, p. 19.

[37] Wolff 1740a, §19; see 1725, Preface, sig.):(5 3; 1727–9, 1, sig.):(4 1.

[38] This work also states that experiments are useful to discover new truths. See Murray, Harper, and Wilson 2011.

dogmatic physics will build.[39] The latter is based on experiments, but also on demonstrative arguments. Moreover, physics borrows some principles from general cosmology (Wolff 1740, §94). This is the part of metaphysics that establishes the features of any possible world (§78) by means of demonstrative arguments from ontological principles (1737a, §2). Within cosmology as 'within the whole of philosophy', experience makes it possible to 'confirm *a posteriori* dogmas established *a priori*' (§4 n.) Thus, for instance, empirical psychology precedes rational psychology and provides some principles for it (1738, §4). However, rational psychology is not only based on experience. It also establishes some claims a priori.[40] Some of its a priori arguments lead to conclusions that empirical psychology proves a posteriori (§5), confirming the conclusion of rational psychology. Similarly, experimental teleology is an aid to natural theology, which contains a priori arguments (École 1979a).

Wolff's statements on the relations between the sciences make clear that, although he follows experimental philosophers in praising observations and experiments, he does not follow them in rejecting a priori arguments. Wolff often uses the phrase 'marriage of reason and experience' (*connubium rationis et experientiae*) to capture the main thrust of his system.[41] In the spirit of that phrase, Wolff combines experiments with hypotheses. He emphasises the experiential basis of philosophy, while integrating it with a priori arguments. He endeavours to develop thoroughly experiential or experimental sub-disciplines, like empirical psychology and experimental physics, but he combines each of them with a sub-discipline that relies at least in part on a priori arguments, like rational psychology and dogmatic physics. Accordingly, rather than being a thoroughly experimental philosophy, Wolff's system appears to be a combination of experimental or experiential sub-disciplines with sub-disciplines that employ speculative arguments decried by experimental philosophers.

To assess whether this suggestion is correct, we must examine Wolff's notion of the a priori. As Wolff has a weak or unconventional notion of the a priori, he may state that some claims of dogmatic physics or rational psychology are established a priori even if they ultimately rely on experience.

7.3 A Priori Cognitions and Philosophy as a Demonstrative System

As it turns out, Wolff's notion of the a priori is so weak that early modern experimental philosophers could have easily admitted the existence of a priori truths in Wolff's sense. Wolff does not adopt the old notion of a priori proof as

[39] Wolff 1740a, §109. Wolff's experimental and dogmatic physics are only two parts of his natural philosophy, which also includes cosmology, meteorology, geology, botany, physiology, pathology, and teleology.

[40] Wolff 1738, §4; 1740a, §112 n.; École 1966, pp. 592–8.

[41] For example, in Wolff 1735a, p. 682 n.; 1738, §497; 1740b, §1232; 1741, 5, §312. For a similar expression, see Leibniz 1971 [1669–70], p. 538.

a proof of statements about effects from statements of their causes, nor does he adopt the later notion of a priori truth as a truth that is independent from experience.[42] Wolff calls a truth a priori if it has been established by means of an inference:

> *Indeed*, either *we make use* of our own capacities to *establish* [*truths*] *only by means of our sense*[*s*], or else *we derive yet unknown* [*truths*] *by inferring them from other cognitions*. In the former case we are said *to discover the truth a posteriori*, whereas in the latter case [we are said to discover it] *a priori*. (Wolff 1740b, §663)

For Wolff, all inferences can be formulated as syllogisms (*ratiocinia*) (Wolff 1740b, §§421–98). We discover truths a priori when we establish them by means of syllogisms (1738, §460), regardless of whether their premises have been established empirically or independently of experience.

When all the premises on which we rely have been established by means of inferences, we are employing what Wolff calls pure reason. When some of those premises have been established non-inferentially on the basis of experience, we are employing impure reason (1738, §495). Wolff calls the cognitions that we acquire by means of impure reason mixed cognitions. For instance, if we combine the observational statement that the Sun emits light with the premise that the cause of the light is fire, we can infer the mixed cognition that the Sun is made of fire (§434).

We rely on pure reason only 'in arithmetic, geometry and algebra . . . Reason in physics is the least pure, because everywhere within physics we accept truths known *a posteriori* about [material] things, as is common in astronomy as well' (§495). Indeed,

> Even in abstract disciplines, like *first philosophy*, the fundamental notions must be derived from experience, which provides the foundation of factual cognition [*cognitionem historicam*] . . . *moral* and *civil philosophy*, too, derive principles from experience. Indeed, even *mathematics* presupposes some factual [*historicam*] information from which it derives the notion of its object and some axioms. I am referring to *pure mathematics*, as this is [even] more apparent with regard to mixed mathematics. (Wolff 1740a, §12)[43]

[42] The old notion of a priori proof was adopted, for instance, in Heineccius 1733, p. 125. The later notion can be found in Lambert 1764, 1, p. 414.

[43] We learn factual information 'thanks to the senses' (§1). As the quoted passage makes clear, the claim that Wolff views 'metaphysics as a demonstrative a priori science' (Hettche 2016, §2) is true only on a weak sense of the term 'a priori'. *Pace* Tonelli (1975, p. 247), ontology for Wolff is not 'completely a priori *strictu sensu*'. For a helpful discussion of the roles of experience and a priori elements in Wolff's philosophy of medicine, see Favaretti Camposampiero 2016.

Wolff's 'marriage of reason and experience' is nothing more than the 'cooperation of reason' (that is, inferential knowledge) 'and experience' (Wolff 1738, §497) that takes place 'when reason is not pure' (§496). It need not be a combination of empirical knowledge with cognitions that, being acquired or justified wholly independently of experience, are a priori in a strong sense of the term. The marriage of reason and experience takes place, for instance, when experiments confirm conclusions previously arrived at by means of inferences. This is what Wolff has in mind when he mentions experiments that confirm a priori claims. For Wolff, experience can provide the ultimate foundation of an a priori claim, as long as that claim has been derived from experience by means of inferences.

Experimental philosophers would agree that there are a priori cognitions in Wolff's sense of the term. However, they would stress that none of these cognitions is a priori in the stronger sense of being established on the basis of premises all of which are established independently from experience. To determine whether Wolff would agree with this view, we must examine the structure and foundations of his demonstrative system.

As is well known, Wolff's two series of philosophical treatises (written, respectively, in German and in Latin) adopt a mathematical demonstrative method.[44] Each treatise covers one discipline or sub-discipline. Basic disciplines establish claims on which the remaining disciplines rely. For instance, physics employs claims established within cosmology (1740a, §94), which borrows some propositions from ontology (1737a, §9). In each treatise, a series of numbered propositions are demonstrated by means of syllogistic arguments from propositions established either earlier on in the treatise or in treatises devoted to more basic disciplines.

The whole system relies on axioms, that is, self-evident propositions that are typically introduced at the beginning of Wolff's treatises. Wolff holds that, although we can accept axioms as true simply because they are self-evident, we can also establish their truth by means of arguments (Hettche 2016, §6). Several axioms are clearly based on experience (e.g., Wolff 1736, §27). Other propositions are not self-evident and are introduced later on in Wolff's treatises. Of those, some are introduced on the basis of empirical remarks (e.g., 1738, §501). Others are introduced on the basis of a combination of empirical remarks and previously proven propositions (e.g., 1740b, §5).

Wolff's empirically based propositions can be found in every area of his system. They include, among others, natural philosophical claims on the existence of corpuscles (1737a, §228), psychological claims on our consciousness of the external world (1738, §11), and logical principles like the law of

[44] For a defense of the claims of this section, see Vanzo 2015, pp. 244–54.

non-contradiction.[45] Wolff relies on experience in the most basic and abstract discipline, ontology, and even in a discipline like cosmology[46] which, he claims, derives entirely from ontological principles (§2). Acknowledging this is important for realising that the whole of Wolff's philosophy can be aptly characterised as a *philosophia experimentalis universalis*, a philosophy that relies on experience at every level.[47]

Appeal to experience is not the only way, besides inference, in which Wolff introduces new propositions. A striking feature of his system is the huge number of definitions. Wolff has a theory that specifies which definitions are acceptable (1740b, §§152–97). In many cases, however, he does not explain why we should accept specific definitions. This contributed to building the image of Wolff's system as a speculative castle in the air, based on arbitrary stipulations rather than experiments and observations.[48] Yet, while some of Wolff's definitions appear to be stipulative, others appear to express or regiment current linguistic usage or to be based on experience. At any rate, Wolff does not usually attempt to vindicate his definitions by showing that they are based on experience or on conceptual analysis. All that Wolff expects from his readers is to accept that his definitions are true, so that he can use them as the basis for subsequent arguments.

The same applies to many of the propositions for which Wolff provides empirical justification in addition to a priori arguments. For instance, Wolff holds that we can come to know that we are conscious of ourselves and other things by paying 'attention to our perceptions' (1738, §11). He then formulates a refutation of a hypothetical opponent. The refutation relies on the assumption that one can only doubt something if one is conscious (§12). It would be natural to regard this as an analytic, non-empirical claim on the meaning of 'to doubt'. However, Wolff is not concerned to specify whether that statement, or his argument as a whole, is empirical or non-empirical. He is only concerned to establish his claim regarding consciousness, so that he can use it as a premise for subsequent demonstrations.

In order to establish his claims, Wolff does not hesitate to combine various forms of justification. This is evident in his defence of the principle of sufficient reason in the Latin *Ontology*. After its first appearance in the German *Metaphysics* (1751, §30), Wolff's principle of sufficient reason was subject to

[45] Wolff 1736, §27. Other propositions that derive entirely or in part on experience are found, for example, in Wolff 1736, §§27, 52, 74; 1738, §§62, 68, 82, 91, 501; 1740b, §§3, 4, 13, 30, 31, 32, 60.

[46] See, for example, Wolff 1737a, §§51, 52, 53, 54, 228, 231.

[47] This expression appears in the subtitle of Cataldi Madonna 2001a.

[48] See, for example, Kant's *Träume eines Geistersehers*, 2: 342.

vehement attacks. In response to them, Wolff's *Ontology* adduces many reasons for endorsing it:

1. a proof based on earlier propositions (1736, §70);
2. remarks intended to show that the law of sufficient reason is consistent with our experience (1751, §72);
3. a defence of the view that we can regard the law of sufficient reason as an empirical generalisation (1736, §73);
4. the claim that, psychologically, we would find it difficult to believe that something is the case although there is not any reason for it to be the case (§74);
5. the claim that the law of sufficient reason is an axiom, hence it is self-evident (§75).

Several of these remarks, including the proof in §70, are based at least in part on experience.[49] However, Wolff does not stress this. He is not concerned to persuade his readers that the principle of sufficient reason is true because it has an empirical foundation. He is only concerned to persuade his readers that the principle of sufficient reason is true. He musters every consideration, empirical or otherwise, that he thinks will help him achieve that aim.

This indicates that quite often, Wolff does not focus on building a system on empirical foundations, but on building a system on foundations that his readers will accept as solid. Hence, when Wolff takes a definition or proposition to be sufficiently uncontroversial, he may introduce it without further justification (e.g., 1740b, §219). He may claim rhetorically that no one would question it (§30), or he may state that its truth can be seen from examples (§109). When Wolff argues for a proposition whose empirical foundation he finds apparent, his reference to experience may be rather sketchy, especially if compared with the extensive empirical evidence often adduced by Boyle or Newton in support of their claims. Often, when a proposition is not an axiom, Wolff only shows that it is a priori in the etymological sense of being based on prior propositions. He does not point out whether those propositions include empirical premises, although that is typically the case.

Wolff's mathematical method is compatible with the development of a system entirely based on experience. The method allows indiscriminately for 'definitions, undoubted experiences, and axioms' (Wolff 1740b, §498) as premises for demonstrations. Definitions and axioms can be based on experience, although Wolff's mathematical method does not require this. It only

[49] Among the premises of that proof is Wolff 1736, §53. It derives from §52, whose truth 'we experience for the very nature of our mind'. We know it through introspection, which for Wolff, as for a number of experimental philosophers, is a form of experience. See Wolff 1738, §436; Boyle, *The Christian Virtuoso, 1*, B 11 307; Feijóo y Montenegro 1726–39, 7, pp. 313–14.

requires that the system has 'certain and unmoved principles' (1740a, §30). Empirical statements can fulfil this requirement. When they do, Wolff calls them undoubted experiences. Those experiences have withstood rational and empirical scrutiny, yet they are by no means indubitable.[50] Wolff's pragmatic stance[51] does not require him to achieve absolute certainty or to chase away Cartesian demons before establishing the foundations of his system.

As Wolff does not aspire to make the premises of his system demon-proof, so he does not endeavour to show that all of those premises are based on experience. While he is keen to show the empirical basis of many claims, he introduces others without referring to experience. When he takes their truth to be potentially controversial to his (pragmatically minded) readers, he does not hesitate to adduce a host of different reasons for accepting those claims. These reasons typically include empirical arguments. However, exhibiting the empirical foundation of Wolff's premises is far less important in his eyes than dispelling any reason for his readers to doubt them.

In conclusion, Wolff shares many commitments with experimental philosophers, far beyond what most commentators have acknowledged. Wolff emphasises the importance for philosophy to have a thoroughgoing foundation in experiments and observations. He allows for the use of hypotheses within natural philosophy in a way that is consistent with the views of refined experimentalists. He also allows for a priori knowledge, but his notion of a priori is so weak that experimental philosophers would find it unproblematic. Nevertheless, Wolff combines his commitment to build a 'universal experimental philosophy' with a commitment to develop philosophy as a deductive system based on firm foundations, and his concern to ensure their soundness overshadows his concern to found philosophy on experience. It is only in the second half of the eighteenth century that we can find a more straightforward and thoroughgoing endorsement of experimental philosophy by German authors. But before we turn to these developments, we should examine another significant appearance of the ESD in the first half of the century, namely, in the reorganisation of the Berlin Academy by Frederick the Great and his most strategic appointment, Pierre-Louis Moreau de Maupertuis.

7.4 Experimental Philosophy and the Berlin Academy

The Berlin Academy was founded by Leibniz in 1700, and initially it flourished; by 1740, however, it had long been in decline. In 1744, Frederick the Great set about renewing this institution in order to establish his kingdom as an intellectual centre rivalling Paris and London. To achieve this he made two strategic moves. First, he restructured the classes of the Academy along

[50] See Arndt 1986, p. 34; Cataldi Madonna 1987, p. 34.
[51] Cataldi Madonna 1984, p. 26.

disciplinary lines that reflected recent developments in the sciences and arts; and second, he invited perhaps the most celebrated French natural philosopher of the day, Maupertuis, to become its perpetual president. Let us examine each of these developments in turn.[52]

The Academy's original structure in 1710 included four classes:

1. Natural philosophy (including medicine and chemistry)
2. Mathematics (including geometry and mechanics)
3. German language and history
4. Oriental literature and work for the propagation of the Gospel.[53]

These were restructured by Frederick in 1744 as follows:

1. Natural Philosophy (*Physique*)
2. Mathematics
3. Philosophy (*Philosophie*)
4. Philology.[54]

Medicine was omitted, and the study language and antiquities was expanded to philology, that is, the full range of *belles-lettres*, by dropping the focus on German and oriental antiquities. One distinctive feature of the new arrangement was that it brought together in a more overt way all the sciences and arts under one institution. As Jean Henri Samuel Formey, the Secretary of the Academy, put it, 'The four classes, which compose the academy of Berlin, embrace all the subjects which elsewhere are the object of two distinct academies, that of the sciences and that of literature' (Formey 1746, sig.)()(1^{v}).

Then in June 1746, after the arrival and appointment of Maupertuis as President of the Academy, the classes were revised again. We quote from the 'Rules for the Royal Academy of Sciences and Belles-Lettres':

> The king . . . wanting to give to this company a final form more appropriate to augment his lustre and its progress, his majesty ordered that from now on it observe the following rules:
>
> 1. The Academy will continue as it is, divided into four classes:
>   1. The class of experimental philosophy will include chemistry, anatomy, botany, and all the sciences which are founded on experiment.
>   2. The class of mathematics will include geometry, algebra, mechanics, astronomy, and all the sciences which have as their object abstract extension and number.
>   3. The class of speculative philosophy will apply to logic, metaphysics, and morals.

[52] For a more detailed discussion, see Anstey 2022.
[53] Formey 1750, p. 31.
[54] Formey 1750, p. 67.

4. The class of *belles-lettres* will include antiquities, history, and languages.

(Formey 1748, pp. 3–4)

The class of natural philosophy (*Physique*) is now called 'experimental philosophy' (*Philosophie expérimentale*). It was to include chemistry, botany, and all the sciences founded on *expérience*. The class of philosophy was renamed 'speculative philosophy' – a label that, as d'Alembert noted, was unique to the Berlin academy[55] – and was to include logic, metaphysics, and morals. And philology was henceforth to be called *belles-lettres* and to include the study of antiquities, history, and languages. Each class was to have a permanent director and up to twelve ordinary academicians as members.

Here then, in the third most important scientific academy in Europe, the pair of experimental philosophy and speculative philosophy is enshrined in the institution's structure. This is a striking development in the spread and impact of experimental philosophy on the Continent. And yet the manifestations of both experimental and speculative philosophy within the Academy have some distinctive features that are worthy of comment.

In the first instance, it is worth noting the spread of sub-disciplines: chemistry, anatomy, botany, and other sciences founded on *expérience* fall under the remit of the class of experimental philosophy, while mechanics and astronomy come under the class of mathematics. Newton would have been aghast. The location of mechanics and astronomy in the class of mathematics rather than experimental philosophy, however, almost certainly reflects the influence of Leonard Euler, Europe's premier mathematician, who was Director of the class of mathematics and actively working on problems in mechanics and astronomy. Moreover, both Euler and Europe's other leading savant working on problems of mechanics and astronomy in the early 1740s, d'Alembert, advocated a form of rational mechanics in which the laws of motion were thought to be discovered a priori.[56] To be sure, d'Alembert's views concerning the relation between experiment and mechanics were subject to change from the publication of his *Traité de dynamique* in 1743 and his exposure to British experimental philosophy over the next few years.[57] However, in 1746 there was certainly no compulsion in Berlin about placing mechanics or astronomy under the auspices of the class of experimental philosophy.

[55] Aarsleff 1989, pp. 197–8. Four decades later, the Paduan Academy of Sciences, *Belles-lettres* and Arts adopted the same labels and division into four classes of the Berlin Academy. The class of experimental philosophy encompassed 'all disciplines and arts that are founded upon observation and experience'. The class of speculative philosophy encompassed 'metaphysics with its branches' (Accademia di scienze, lettere ed arti 1780, art. IV.1).

[56] See T. L. Hankins 1970, pp. 178–9.

[57] See Anstey 2014b, pp. 508–9.

A more striking feature of the new classes of 1746, however, is the apparent lack of antagonism between experimental and speculative philosophy; they sit together as complementary 'disciplinary clusters'. Indeed, the object of the Academy was for academicians to actively engage in classes other than the one to which they belonged. Far from railing against the dangers of speculative philosophy, savants in Berlin were actively encouraged to work alongside and engage with those who practised the 'speculative sciences'! How are we to account for this?

Part of the explanation of this is the manner in which speculative philosophy was redefined in terms of its objects of study rather than according to methodological and epistemic criteria. When Formey elaborated on the class of philosophy before it was rebranded as the class of speculative philosophy, he focused on the objects of study of metaphysics:

> Metaphysics is without doubt the mother of the other sciences, the theory that provides the most general principles, the source of the evidence and foundation of the certainty of our knowledge. These beautiful features do not apply, in truth, to the metaphysics of the scholastics, a barren land, which really only produces briars and thorns. . . .
>
> The great geniuses, in re-cultivating this portion of the empire of the sciences made it assume a different face. Instead of a dictionary of barbarous terms, we are beginning to have a nursery where each science finds, so to speak, its seeds, and from which are born all the principles that guide us whichever way we turn.
>
> Furthermore, the examination of these subjects demands minds free from the barriers of superstition that reign in many countries, where one has not fixed in an accurate way the limits of reason and faith, and that we find ourselves in this regard in the most favourable situation that one could wish for. (Formey 1748, sigs.)()(1v–)()(2^{v})

Note the implicit commitment to the neo-Aristotelian theory of knowledge acquisition: metaphysics is the science that provides 'the most general principles' as foundations for the certainty of the other sciences. Note too, the criticism of Scholastic metaphysics, so de rigueur at this time[58] and the call to free ourselves of superstition. Formey's vision, which reflected his Wolffianism and was shared by many within the Academy, was of metaphysics as a kind of meta-science standing above all the others and furnishing them with common principles, which, when combined with the proper principles of each specific science, will yield a science that can be known with certainty. Ontology has the same status in the scheme of knowledge that prefaces the *Encyclopédie*.[59] This

[58] See, for example, Hume's *An Enquiry Concerning Human Understanding*, Hume 2007b, p. 120.

[59] See d'Alembert 1995 [1751], pp. 144–5. See also d'Alembert and La Chappelle's article 'Elemens des sciences', *Encycl.*, 5, pp. 491–7.

agreement was to be expected, given that Formey was a Wolffian and that numerous entries of the *Encyclopédie*, including the entry 'Ontology', were tacit paraphrases of Wolffian texts.[60] This is all a far cry from the speculative philosophy that was the bête noire of the early Royal Society, which was defined using methodological and epistemic criteria, such as the uncritical use of hypotheses without adequate recourse to observation and experiment and the tendency to build systems upon them.

When Frederick reorganised the academy, he rebranded the class of philosophy as a class of speculative philosophy, while adopting a disciplinary meaning of 'speculative'. This enabled him to use the then-popular ESD, while avoiding the implicit criticism that was associated with uses of 'speculative' in England and France.[61] Thus, speculative philosophy came to be defined by its objects of study. As Maupertuis later put it in his 'On the duties of the Academician' of 1750: 'The Supreme Being, the human mind and all that which belongs to the mind is the object of this science. The nature of bodies themselves, as represented by our perceptions, if they are different from these perceptions, is its concern' (Maupertuis 1750, p. 120). Maupertuis, moreover, positively encouraged all members of the Academy to pursue it, though with appropriate caution: 'All is permitted to the philosopher, provided that he treats all with the *esprit philosophique*, that is to say, with that mind which measures the different degrees of assent, which distinguishes evidence, probability, doubt and which only presents its speculations under that of these different aspects to which they belong' (Maupertuis 1750, p. 121). All of this coexisted in Maupertuis' writings on the Academy with a general aversion to system building and hypotheses,[62] though there was methodological diversity amongst the academicians. Thus, the form of speculative philosophy that comprised one of the four classes of the Academy was in many ways different from speculative philosophy as it had normally been construed. It was in the Academy not just a legitimate subject of study, but something that was actively promoted and comprised a class with an identifiable membership and active director, namely, Samuel Formey.

Frederick's second strategic move in revivifying the Academy was the appointment of Maupertuis as President. Maupertuis was the French experimental philosopher par excellence:[63] the one-time natural historian, critic of

[60] Carboncini 1987; Carboncini-Gavanelli 2007.

[61] Maupertuis acknowledged that 'perhaps, if [he] had created the structure of the Academy, [he] would not have had the courage to introduce' a class of speculative philosophy; 'but having found it there', he was 'very pleased' (Aarsleff 1989, p. 198). On the meaning of 'speculative philosophy' in the Berlin Academy, see Leduc 2020.

[62] Maupertuis 1750, pp. 116, 118.

[63] J. B. Shank argues that initially Maupertuis did not identify with the emphasis on experimental philosophy in the Newtonianism of Voltaire, Desaguliers, and 's Gravesande; however, by the publication of the second edition of Maupertuis'

systems,[64] the leader of the Lapland expedition, and the perpetual President of the Academy, the one to whom the French savant Louis Guillaume Le Monnier had dedicated his translation of Roger Cotes' lectures on experimental philosophy.[65] His appointment was a significant coup for Frederick; apart from d'Alembert, it is difficult to name a more famous or significant natural philosopher in Europe at the time. Yet in spite of these credentials, from the time of his appointment in February 1746 to his death in 1759, Maupertuis did not publish a single article in the memoirs of the class of experimental philosophy or, for that matter, the class of mathematics. Instead, all of his significant contributions to the Academy's memoirs were in the classes of speculative philosophy and *belles-lettres*. This includes his extended treatment of his signal contribution to mechanics, namely the Principle of Least Action, which appeared as 'The laws of motion and rest deduced from a metaphysical principle' in the memoirs for the class of speculative philosophy.[66]

What this tells us is that the constitution of the Berlin Academy reflects a different understanding of the relationship between experimental and speculative philosophy from that which was prevalent in England and France. They were not at loggerheads, demarcated along epistemic criteria. While this was the result of Frederick's reorganisation, it is also consistent with Wolff's emphasis on the marriage of reason and experience, with Leibniz's[67] original plans for the academy to 'unite in a happy wedding theoreticians and observers', and with Tetens' later call for a combination of experimental and speculative philosophy (Section 7.6).

7.5 Experimental Philosophy and Empirical Psychology

In the second half of the eighteenth century, German philosophers became familiar with the works of a broader range of experimental philosophers and those attempting to apply experimental methods than those to which earlier authors such as Wolff had access. In addition to Locke and Newton,[68] German authors engaged with the works of Hutcheson,[69] Lord Kames, Alexander

Discours sur les différentes figures de astres (1742), this all changed. See Shank 2008, pp. 290–2 and pp. 421–3.

[64] For his critique of systems, see his seventh letter in Maupertuis 1768, 2, pp. 257–61.

[65] See Le Monnier 1742, sig. a iij.

[66] Maupertuis 1748.

[67] Leibniz 1971 [1669–70], p. 538.

[68] See Pollok 2004, pp. xxv–xxviii on Locke; Ahnert 2004 on Newton.

[69] Hutcheson's works were translated into German between 1745 and 1768 and influenced German authors both directly and indirectly, through Addison's essays and Pope's poems; see Puech 1992, p. 183. For instance, Kant discussed Hutcheson's views several times from the early 1760s onwards; see Henrich 1957–8.

Gerard,[70] d'Alembert, and especially David Hume. As Manfred Kuehn has shown,

> By 1755 Hume is referred to as a well-known author who no longer needs any introduction. . . . By 1760 all of Hume's major philosophical publications, the (anonymous) *Treatise* excepted, were translated into German. . . . There are also numerous references to his writings by German philosophers, theologians and historians in many different contexts. And in *some* of these writings Hume's arguments are taken very seriously. (Kuehn 2005, p. 103)[71]

The works of Thomas Reid and other Scottish common-sense philosophers, too, were regularly reviewed in German journals and became widely known.[72]

Despite the substantive differences between the views of Locke, Hume, and Reid, German authors regarded them as contributing to the tradition of early modern experimental philosophy, primarily through their work on the empirical study of the mind. It is within empirical psychology, rather than natural philosophy, that the influence of British experimental philosophy was most prominent. While both branches of Wolff's psychology, empirical and rational psychology, set off from experience and refer frequently to it,[73] most advocates of the development of empirical psychology from the 1750s onwards placed more emphasis than Wolff on the necessity of grounding psychology on an extensive empirical basis and of developing it according to the methodological dictates of experimental natural philosophy.

The empirical study of the mind soon became a popular endeavour. As the historian Johann Gottlieb Buhle wrote at the end of the century, interest in a priori metaphysics became 'limited to the lecture rooms of philosophy professors'. Many German philosophers turned from a 'metaphysics based

[70] Puech 1992, pp. 185–6.

[71] See Kuehn 1987a, pp. 48–58, *pace* Tonelli 1966 and Gawlick and Kreimendahl 1987. Among the works that took Hume seriously were those of the anti-Wolffian members of the Berlin Academy, such as Maupertuis and Johann Bernhard Merian (who translated Hume's *Natural History of Religion*); works by authors close to Wolff such as Johann Georg Sulzer and Jean Henri Samuel Formey (both of whom translated Hume's *Enquiry Concerning Human Understanding*), Moses Mendelssohn, and Johann Heinrich Lambert (see Kuehn 1995, p. 201; 2005, pp. 104–9; Watkins 2005, pp. 364–7); and essays by interlocutors of Immanuel Kant such as Johann Nicolaus Tetens and Johann Georg Heinrich Feder. For instance, Tetens discussed Hume's views on the self (Tetens 1777, pp. 392–5) and causality (pp. 316–27), as well as Hume's rejection of speculation in favour of a philosophy based on observation (Tetens 1913 [1775], pp. 11–2; see Kuehn 1989; 2005, pp. 112–14; Watkins 2005, pp. 368–72). Feder defended Hume against Tetens' criticisms in a review of his *Philosophical Essays*; see Feder 1777, pp. 520–3. For the attribution of this review to Feder, see Übele 1911, p. 181, n. 3.

[72] Kuehn 1987b, pp. 52–69.

[73] On the prominent role of experience in Wolff's rational psychology, see Dyck 2014, pp. 19–42.

on concepts' to 'empirical philosophy, especially empirical psychology and ethics', making the 'empirical philosophy of the nature of the mind' a 'fashionable subject of study' (Buhle 1800–5, 6.2, pp. 507–8).[74] Several well-known authors published works on empirical psychology, including three of Kant's early critics, Johann Georg Heinrich Feder (1779–93), Christoph Meiners (1786b), and Johann Christian Lossius (1775), as well as Johann Nicolaus Tetens (1777), to whom we turn in the next section.

The terms with which German authors designated empirical psychology emphasised the centrality of experience and, on the face of it, even experiment. As we have seen, in the 'Preliminary Discourse' of the *Encyclopédie*, published in 1751, d'Alembert famously wrote that Locke 'reduced metaphysics' to 'the experimental natural philosophy [*Physique expérimentale*] of the mind' (PD, 84, translation modified).[75] German authors echoed this statement, not just by characterising empirical psychology as a 'physics of the mind' – an expression that, according to Immanuel David Mauchart (1792, p. vii), designates the 'peculiar character', 'purpose and destination' of psychology – but also by qualifying psychology as an *experimental* discipline. In 1756, Johann Gottlob Krüger published an *Essay on Experimental Psychology* [*Experimental-Seelenlehre*]. Three years later, the Wolffian author Johann Georg Sulzer (1759, §204) described empirical psychology as an 'experimental physics of the mind'.[76] In 1760, Tetens lamented the limitations of experimental psychology and stated that, in order to overcome them, more data had to be gathered through experience (Tetens 1760, pp. 61–2).

German authors were aware that a truly experimental discipline should involve experiments, as opposed to mere observations. As Mauchart stated, properly speaking, 'psychology is an experimental psychology only if its general principles are employed in such a way as to cause the occurrence in the human mind of phenomena that would not have occurred at all if those principles had not been employed' (Mauchart 1792, pp. v–vi). For instance, a researcher might employ the principles of experimental psychology to stir in his subjects certain passions that they would not have otherwise experienced.

Instead of carrying out such interventions on the mind, German proponents of experimental psychology mostly retreated from the field of experimentation to the more familiar domain of observation.[77] For instance, Krüger's essay on experimental psychology mentioned the possibility of experimenting on the minds of criminals and non-human animals, based on the assumption that 'one can bring about changes in the mind by bringing about extraordinary

[74] See also Zammito 2002, pp. 237, 245.

[75] Throughout this chapter, we translate 'âme' and 'Seele' as 'mind'.

[76] For an overview of Sulzer's psychological views, see Macor 2011, pp. 31–48. Macor 2011 provides a helpful reconstruction of the developments in empirical psychology outlined in this section.

[77] They did, however, perform some experiments, especially concerning vision.

changes in the body' (Krüger 1756, p. 18). However, he refrained from proposing that such experiments be actually carried out. He held that his psychology can be called experimental simply because it takes into account what medicine teaches us about the body, and it infers features of the mind from it. Lossius argued that the discipline that identifies psychological laws 'is called "experimental psychology" because these laws must be grounded on experience and observation, rather than arbitrary propositions' or improperly applied 'metaphors' (Lossius 1777, 1, p. 185). Lossius' psychology is really only an *experiential* and *observational* psychology, rather than a truly *experimental* psychology. The shift from experimental to observational psychology is also apparent in Karl Philipp Moritz's project of a journal devoted to gathering psychological observations. After Moritz presented this project in his *Prospect for an Experimental Psychology* [*Experimental-Seelenlehre*], Moses Mendelssohn persuaded him to drop the term 'experimental' and to use the more accurate expression '*empirical* psychology' [*Erfahrungs-Seelenkunde*] in the title of the new journal.[78] As we illustrate in the next two sections, other authors such as Tetens settled for expressions such as 'observational [*beobachtende*] philosophy' and 'observational method'.

The observations that form the basis of this empirical psychology were to be obtained primarily through introspection, which was conceived of as a form of observation. As Feder and Tetens explained, 'in order to . . . reach certainty concerning the nature of the human mind [*Geist*], one must first of all *observe oneself*' (Feder 1779–93, 1, p. 11).

> Considering the modifications of the mind, as they are known through our self-awareness; carefully observing their repetition and perceiving them under changed circumstances; noticing how they develop, and according to what laws the forces that bring about those modifications of the mind operate; then comparing observations, analysing them and, on that basis, searching the simplest [mental] faculties and modes of activity and their relation to each other: these are the most essential acts of the psychological analysis of the mind, which rests upon experiences.
>
> (Tetens 1777, p. iv)

Although introspection is an individual exercise, the development of empirical psychology is a collective endeavour. Only once 'others perform similar observations on themselves and communicate them honestly' is it possible 'to draw general consequences' (Feder 1779–93, 1, p. 12). We must study the results of other people's introspective acts and complement them with third-person accounts when first-person accounts were not available, by relying on 'history, biographies, travel reports and the history of peoples

[78] Compare the title of Moritz 1782a with Moritz 1782b, p. 503. Similarly, although Sulzer advocates an 'experimental psychology of the mind', he only mentions observations, rather than experiments; see Sulzer 1759, §§204–6.

[*Völkergeschichte*]' (p. 16). These, alongside collections of psychological case studies, are 'the foundation of a more stable, more useful philosophy' (p. 16).

The best-known collection of psychological case studies that were meant to provide such a foundation is the *Magazine for Empirical Psychology*, edited by Moritz. It was published every four months for ten years, from 1783 to 1793 – a rather long run by the standards of the time.[79] Besides Moritz's, several other 'collection[s] of materials for a future enlightenment in empirical psychology'[80] saw the light, in addition to a plethora of journal articles and book reviews on psychological and physiological themes. These articles and collections covered a broad range of topics, with a focus on psychopathological cases, suicides, and the life experiences that led certain individuals to become criminals; character sketches of specific individuals, especially when endowed with a special moral or pedagogical significance, for instance 'how someone managed to overcome a particular vice, such as anger, pride or vanity' and their 'relapse in these vices' (Moritz 1782a, p. 9); character sketches of pupils and pedagogical reflections. Like Schiller and Goethe, Moritz conceived of the novel as a tool for psychological investigation.[81] He held that psychological case studies could be derived from 'eminently good novels and dramas, such as those by Shakespeare, which are contributions to the inner history of man' (Moritz 1782a, p. 10).[82]

The authors and editors of those case studies did occasionally indulge in theorising. However, by and large, they aimed to merely present facts, setting aside any 'religious or moral preconceptions' (Macor 2011, p. 22) and leaving the task of ordering and reflecting on them to a time when 'enough facts' will be 'available' (Moritz 1782a, p. 10). As experience was the basis for empirical psychology, so empirical psychology was thought to provide the foundations of logic, aesthetics, pedagogy, natural theology, and especially ethics.[83] Empirical psychologists were keen to advertise the usefulness of their endeavours to a broad range of professionals, including educators, judges, physicians, preachers, and religious ministers.[84]

[79] This is noted in Bell 2005, p. 103.

[80] This is the subtitle of one such collection, Mauchart 1789. Other collections include Abel 1784–90, Mauchart 1792–1801, and Pockels 1794.

[81] See Bell 2005, pp. 85–142.

[82] For two lists of the materials to be included in these collections of psychological case studies, see Moritz 1782a, pp. 8–10; Mauchart 1792, pp. 11–14. For a helpful classification of the articles published in Moritz's *Magazine*, see Bell 2005, p. 96.

[83] See Lossius 1775, pp. 8–9; Lossius 1777, 1, pp. 127, 183–4; Abel and Schwab 1778, pp. 397, 399; Mauchart 1792, p. ix. For Meiners (1772, pp. 164, 203), logic and psychology are inseparable. According to Mauchart (1789, p. 14), the first advantage of psychology is its influence on morality. After claiming that, 'if logic is to be useful, it must be psychology', Hißmann (1778, pp. 47, 49) reduces the whole theoretical philosophy to empirical psychology.

[84] See Moritz 1782a, p. 13 and Mauchart 1789, pp. 15–25. See also Abel 1784, pp. xi–xiii and 1786, p. xxi on the necessity of knowing anthropology (*Menschenlehre*) to achieve

The conformity of the empirical psychology advocated by German authors to the dictates of experimental philosophy can hardly be missed. Although German psychologists relied primarily on introspection and observation, rather than experiment, this is not incompatible with the methods favoured by experimental philosophers. As we saw in Chapter 6, experimental philosophers adopted a broad notion of experiment that encompassed experiments and observations, and they regarded introspection as a form of experience. Like experimental philosophers, German psychologists held that theorising should be carried out once extensive collections of experiences are assembled through a collaborative, cumulative endeavour; they held that theories should be derived from experience; and they did not provide any detailed account of how, exactly, theories can be derived from experience. Their methodological views can be seen as the transposition of the method of experimental natural philosophy to psychology. This transposition was a natural consequence of their view that psychology ought to be an experimental physics of the mind and that the method of psychology is nothing else than 'the method of natural philosophy'.[85]

7.6 Tetens on Observational and Speculative Philosophy

One of the main proponents of psychology understood as an experimental physics of the mind, Tetens, is of particular interest, as he devoted an entire monograph to the relation between observation and speculation. It is entitled *On General Speculative Philosophy*. Initially, Tetens planned to publish it as a chapter of his major work, the *Philosophical Essays*.[86] This is the book that Kant had 'always open on his desk' while he was writing the first *Critique*.[87] Tetens eventually decided to publish the essay on speculative philosophy separately, two years before the *Philosophical Essays*. Its stated aim is to discuss several features of general speculative philosophy [*allgemeine spekulativische Philosophie*], including 'its relations to the cognitions of common sense' and 'its relation to *observational* [*beobachtende*] *philosophy*' (Tetens 1913 [1775], p. 1).

Observational philosophy is a philosophy that relies on observation. Observation, in the relevant sense, takes place when we disregard the relation

happiness, virtue, and wisdom. On the relevance of psychology to ethics in Schiller's early writings, see Macor 2011, p. 84.

[85] Tetens 1777, p. iv; see Abel 1786, p. xxxi for a similar statement on the method of anthropology.

[86] Tetens 1777; see 1913 [1775], p. 3. For an overview of *On General Speculative Philosophy*, see Barnouw 1979, pp. 307–19.

[87] See Johann Georg Hamann's letter to Johann Gottfried Herder of May 1779, quoted in Kuehn 1989, p. 366; Vleeschauwer 1934–7, 1, pp. 299–329. Kant shows esteem for Tetens in his *Briefwechsel*, 10: 232, 270, 341, 346 (1778–83).

of our mental representations to the objects they are about, and we regard them as 'something *subjective*, modifications of ourselves' (p. 2). Introspection is a kind of observation[88] that can help us gain an insight into truths 'about God, the human mind, the world, and the relation of the creator to his creatures and humans' (p. 9). We can gain access to these truths 'without previous general speculations on substance, space and time, etc. ... *Reid*, *Home*, *Beattie*, *Oswald*, and also several German philosophers have proven this beyond doubt with their arguments and with the proofs that they have put forward' (Tetens 1913 [1775], p. 10). Tetens' reference to Scottish common-sense philosophers as an example of observational philosophy is quite typical for the German literature of the time. Tetens holds that observational philosophy can give rise to a 'metaphysics of common sense' (p. 8), based primarily on introspection.

Observational philosophers can be guided by a feeling in this search for philosophical truths:

> The feeling [*Gefühl*] of the true, that is, the internal sensation [*Empfindung*] of what is in harmony with our thoughts, what conforms or does not conform to our capacity to understand [*Fassungskraft*], what enters easily into the understanding or what the understanding resists against. May this internal sensation, may this feeling be the guide.
>
> (Tetens 1913 [1775], p. 11)

This feeling is not infallible: Tetens does not hold that it will always lead us to assent to truths. However, even if it did, this would not render speculative philosophy useless:

> If those *philosophical arguments*, that constitute the true *popular philosophy*, were accompanied by such good luck that they only [led us to] accept clear truths ... [even] if we presuppose this unlikely possibility, will we then have good reasons to declare *acroamatic speculative* philosophy useless, or even to bluster against it, as *Beattie* and *Oswald* did?
>
> (Tetens 1913 [1775], p. 11)

Tetens' answer is: no, we will not. 'The cognitions of common sense are the ground that one must cultivate when practising speculative philosophy' (p. 13). The terrain to be cultivated is a stock of fundamental concepts and principles that are at the basis of philosophical reflection. Observational philosophy should rely on introspection to investigate how those concepts derive from sensation. It should distinguish the concepts that are mere figments of the imagination from those that are exemplified in the actual world. Observational philosophy should also inquire into the psychological origins of philosophical

[88] Tetens 1777, 1, p. iv, trans. in Watkins 2009, p. 357.

principles, following the examples of Locke, Hume, Condillac, and some German philosophers.[89]

Speculative philosophy should reformulate those principles by employing precise, well-defined terms. It should look for systematic links between those principles, assess their truth, search for stronger reasons than a mere feeling to believe them to be true (Tetens 1913 [1775], p. 12), and help us resist the influence of passions and prejudices that could sway our observations (p. 15). It should also endeavour to extend the realm of our knowledge to areas in which we can rely on few or no observations, such as the study of God and the mind (pp. 14, 18–19). Finally, speculative philosophy includes 'transcendent philosophy', which studies possible objects in the abstract and the features that they can or must have (p. 18). One can apply transcendent philosophy to actual objects by combining it with observations provided by experimental philosophy.

Tetens' observational philosophy is an empirical psychology and psychologically informed philosophy that fits squarely within the British and German traditions of experimental philosophy and empirical psychology. Tetens is well aware of this. He locates observational philosophy within a tradition initiated by Francis Bacon and continued by John Locke, Lord Kames, David Hume, Edward Search, Etienne Bonnot de Condillac, Thomas Reid, James Beattie, and James Oswald.[90] Tetens himself developed an observational philosophy in the *Philosophical Essays*, which earned him the title of 'the German Locke'.[91]

Tetens' speculative philosophy is rather different from the speculative natural philosophy that Boyle, Newton, and the members of the early Royal Society opposed so vehemently. Tetens' speculative philosophy is not a natural philosophy, but a combination of logic and ontology. Like British speculative philosophy, Tetens' speculative philosophy carries out conceptual analyses, develops theories, and makes use of hypotheses, although its final aim is attaining certainty, and hypotheses cannot yield it. However, Tetens' speculative philosophy does not operate independently from experience and observations. On the one hand, observational philosophy provides data which are the basis for speculation. On the other hand, a sub-discipline of speculative philosophy (transcendent philosophy) provides an a priori conceptual framework that, rather than being rejected, should be combined with empirical information. Thus, instead of following numerous British and French authors in discarding speculative philosophy in favour of experimental philosophy, Tetens holds that we should draw from both kinds of philosophy, which he

[89] Tetens 1913 [1775], pp. 27, 67. As Tetens was writing these words, Kant was attempting to establish in a very different way a set of fundamental concepts and principles in what would become the *Critique of Pure Reason*.

[90] Tetens 1913 [1775], pp. 9, 68–70; 1777, 1, p. iv. For a similar list, see Meiners 1786b, Preface, sig. a5 3–a5 5.

[91] Tetens (1777) describes its method at the beginning of the work (1, pp. iv, xvi–xxi).

identifies, respectively, with the German tradition of Leibniz and Wolff and with the British tradition of Bacon and Locke. Tetens' irenic conclusion recalls Wolff's inclusion of empirical and (weakly) a priori disciplines within his system, as well as Leibniz's call for a 'happy marriage' of 'theoreticians and observers' in his plans for the constitution of the Prussian Academy of Sciences:[92]

> British philosophers may be our models in observing; but they should not be our models in speculative philosophy. . . . New [British] philosophy was first shaped by *Bacon* and later by *Locke*. Neither was a mathematician or an astronomer . . . *Bacon's* [*New*] *Organum*, regarded as a guide to perform observations and extend empirical knowledge, is a masterwork . . . *Locke's books on the human understanding* contain an excellent model for employing that method in the knowledge of our mind and its operations. Yet both of their logics are insufficient on the other side [the speculative side] . . . British philosophy was nearly only an *observational* philosophy, an empirical physics of man. (Tetens 1913 [1775], pp. 68–9)[93]

Looking at German philosophers, Tetens writes that Wolff was a genius in mathematics and Leibniz was not an acute observer.[94] His irenic conclusion is that metaphysicians should combine the skills and methods of British observational philosophers, such as Bacon and Locke, with those of German speculative philosophers, like Leibniz and Wolff.

7.7 Observational Philosophy: Some Examples

Although Tetens was a well-known author, his essay on observational and speculative philosophy does not appear to have been widely read.[95] Nevertheless, several other volumes published in Germany between the 1770s and the 1790s refer to observation, the observational method, and speculative philosophy. Interestingly, they identify Kant's and Reinhold's new philosophies as examples of speculative philosophy.

In the same year in which Tetens published *On General Speculative Philosophy*, Lossius published *The Physical Causes of Truth* (Lossius 1775).

[92] See Leibniz 1971 [1669–70], p. 538.

[93] Tetens, like others (Walch 1721, pp. 639, 667; Knutzen 1747, §20), regards Bacon's *Novum organum* and Locke's *Essay* as logic texts. The theory of philosophical and natural philosophical method was typically regarded as a part of applied logic in eighteenth-century Germany. See Tonelli 1994, p. 3. For Locke's *Essay* as a logic, see Serjeantson 2008.

[94] Tetens 1913 [1775], p. 71. For similar judgements, see Platner 1772, §735 n.; Büsch 1783, p. 219.

[95] According to Übele (1911, p. 17), it was largely ignored. Puech (1992, p. 28) holds that Kant probably did not read that essay. We found no clear-cut evidence that Kant read Tetens 1913 [1775], but only suggestive textual parallels.

This work, which is frequently cited as an example of materialist philosophy in the German Enlightenment, attempts to establish a physiological basis for Beattie's (1770) account of common sense as an intuition of truth. Lossius states: '[In order to discover the nature of the mind,] *thought* was the first thing into which I set out to inquire, namely, solely by means of the observational method. In my view, it is the only one that can be used in these matters' (Lossius 1775, Anstatt einer Vorrede, sig. * 5 2). Carl Friedrich Flögel adopted the same method in his *History of the Human Understanding*, re-edited in 1773 and 1778. In the study of the human mind – he wrote – one should not follow 'the way of speculation' (Flögel 1778, Preface, sig. * 2 3).[96] 'One ought to derive theory out of the given data and not, inversely, data from speculation' (Flögel 1778, p. 7, trans. in Zammito 2002, p. 238).[97] To this end, one should employ 'the method of a natural scientist; to observe man himself or to see him observed by other reliable witnesses, and on this basis try to construct a natural history of human understanding' (Flögel 1778, Preface, sig. * 2 3). This is, by and large, the method employed in the manuals of empirical psychology surveyed earlier on in this chapter.[98]

By the early 1780s, this empirical method was widely accepted. As Moses Mendelssohn lamented in 1786, 'in recent times, Germany's best heads speak of all speculation with contemptuous disdain. One presses for facts, clings merely to the evidence of the senses, gathers observations, heaps up experiences and experiments, perhaps with all too great a neglect of universal principles.'[99] This disdain for speculation influenced the reception of Kant's first *Critique*, first published in 1781. Feder wrote one of the first book-length criticisms of the first *Critique*, 'this whole of the most abstract speculations of logic and metaphysics'.[100] He accused Kant of humiliating 'empirical philosophy, that is, the philosophy which is founded only on observations, on the agreement of all or most human experiences, and on inferences based on the analogy between them, and fully renounces [the employment of]

[96] The preface is absent in the first edition of 1765.

[97] See also Hißmann's (1777, pp. 18–19) contrasts between 'experience' and 'deep speculation', 'spirit of observation' and 'dogmatism'.

[98] It is also the method that informs Jakob Friedrich Abel's (1995 [1773]) plan for high-school teaching of philosophical subjects. Like experimental philosophers, Abel (p. 18) contrasts this 'new method' with the method of the 'ancients', which 'consists of useless definitions, inquiries and distinctions' and turns a pupil into 'an empty chatterbox, not a wise man'.

[99] Mendelssohn 1786, p. 4. See also Selle 1782, sig.)(2 1: 'There was a time when only theories were accepted. Now is the time of observations.'

[100] Feder 1787, p. iv, see p. xviii. Along similar lines, Meiners (1786b, Preface) criticises Kant's 'transcendentish [*sic*] speculations' (sig. b1 1), 'independent from any experience' (sig. b5 5). Replying to Feder, Schaumann (1789, p. vi) refers to Kant's followers as 'friends of speculation and critique'. See also Schmid 1788c, p. 166, based on A855–6/B883–4.

demonstration[s] based on concepts in the study of nature' (Feder 1787, pp. ix–x).

In the opposite camp, Karl Leonhard Reinhold looked back at the fate of German philosophy between Wolff and Kant. Once Wolffian philosophy lost its predominance, philosophers had abandoned 'the field of speculation' and entered 'the field of observation', giving rise to an 'observational philosophy' (Reinhold 1789, p. 3); an 'observational, gathering, narrative, and additionally also fantasising philosophy'.[101] Reinhold's thought at this stage was an original development of Kantian themes. Since Kantianism was labelled as speculative philosophy, it is not surprising that Reinhold defended speculation against observational philosophy: 'neither common understanding [common sense], nor the healthy understanding, but only reason guided by principles and trained through speculation could succeed in the study of experience'.[102]

Reinhold used the dichotomy of observation and speculation to oppose observational philosophers. Among them, Ernst Platner used the same dichotomy to distance himself from Kant. He opened his *New Anthropology* by declaring that it only contains 'observations and ideas of its author. It does not contain any discussion of speculative metaphysics, especially of the Kantian variety.'[103] Along similar lines, a reviewer introduced Platner's *New Anthropology* to his readers as a 'work of observational philosophy, from a man whose knowledge of the foundations of speculative philosophy and whose capacity to employ it cannot be denied' (Anon. 1790, p. 1577). The reviewer added that Kant himself recognised the usefulness of the philosophy of experience [*Erfahrungsphilosophie*] in addition to speculation. However, there was the risk that, under the influence of Kant's disciples, the tide would turn too strongly toward 'mere speculation and a priori deliberations' (p. 1578).

The reviewer's fears were, by and large, justified. With the rise in the popularity of Kantian and post-Kantian systems from the last decade of the

[101] Reinhold 2011 [1791], p. 24. 'Gathering' refers to the experimental philosophers' programme to build a large inventory of natural philosophical and psychological observations. 'Narrative' refers to the use of an accessible style that would appeal to a broad public. Eberstein 1794–9, 1, pp. 321–2 echoes Reinhold; see also Will 1788, pp. 11, 12. On Hegel's later defence of speculation against common-sense philosophy, see Kuehn 1987b, pp. 234–7.

[102] Reinhold 1789, pp. 3–4. On the meaning of 'common understanding' and 'healthy understanding', see Selle 1788, pp. 17–18: 'insofar as the understanding knows the connection of very abstract concepts, it is called *speculative*, whereas it is called *plain*, *common* or *healthy* if it limits itself only to the perception of physical relations and immediate consequences'.

[103] Platner 1790, Preface, sig. a5 5. In an earlier work, Platner distinguishes talent in the observation of nature from talent in speculation (1772, §§732, 735). The first work in which Platner confronts Kant is the third edition of his *Philosophical Aphorisms* (1793). It starts by praising experience, common sense, and Tetens' *Essays* (pp. vi–viii).

eighteenth century onwards, observational philosophy lost prominence in Germany as a distinctive philosophical movement.[104] This is reflected in a comment by Christian Garve in a description of the observational method. Like Tetens, Garve refers to Bacon and Hume as models of the employment of that method.[105] Garve writes, 'it seems that in our time observation [*das Beobachten*], which was formerly regarded as one of the first accomplishments of the philosophical spirit and the foundation of our scientific cognitions, since its object has been designated with the name of *empirical*, has fallen in discredit with some people' (Garve 1796, pp. 399–400). 'With some people' is an understatement, which reflects Garve's dislike for Kantianism.[106] Observational philosophy came to be often labelled as empirical or, to use Kant's and Reinhold's term, as empiricism. Once the notions of empiricism and rationalism were introduced, the dichotomies of observation and speculation, experimental and speculative philosophy would quickly lose currency.

7.8 Conclusion

Based on the evidence provided in this chapter, we can conclude that Kant and his peers were well aware of early modern experimental philosophy, as it exerted a significant influence on German authors in both the first and the second halves of the eighteenth century. In the first half of the century, Wolff agreed with many of the views of experimental natural philosophers, and he sought to develop a thoroughly experimental philosophy, although this commitment was overshadowed by his concurrent commitment to build a wide-ranging system based on a mathematical demonstrative method. In the second half of the century, several authors sought to apply the methodological approach of experimental philosophy, especially in their attempts to develop an empirical psychology. Even more authors adopted the distinction between experimental and speculative philosophy to frame their own research and to make sense of the rise of Kantianism. While Kant and post-Kantian philosophers, too, occasionally contrasted observational and speculative methods, they typically presented their systems as providing a synthesis of reason and experience. This came to be encapsulated in histories of philosophies in the image of the Kantian synthesis of empiricism and rationalism. It is to the origin of these notions that we turn in the next chapter.

[104] While some Kantians, like Carl Christian Erhard Schmid, were engaged in empirical psychology, and others, like Jakob Friedrich Fries, attempted a psychological foundation of transcendental philosophy, they largely abandoned the epistemological and methodological tenets of experimental philosophy.

[105] Garve 1796, pp. 297, 401, 403, 405, 427. Garve also mentions Montaigne and Montesquieu, to whom Tetens does not refer (pp. 403, 405).

[106] Garve was largely responsible for the first, negative review of Kant's *Critique of Pure Reason* (Garve and Feder 1782).

CHAPTER 8

Kant and the Genesis of Empiricism

While both the historical movement and the notion of experimental philosophy were losing prominence in late eighteenth-century Germany, the historiographical notion with which experimental philosophers are most frequently associated started gaining currency. This is the notion of empiricism, which, along with its counterpart, rationalism, forms the centrepiece of a narrative of early modern philosophy which dominated the English-speaking world throughout the twentieth century.[1] According to this narrative, the early modern period was characterised by the development of two rival schools: the rationalism of Descartes, Spinoza, and Leibniz and the empiricism of Locke, Berkeley, and Hume. Empiricists and rationalists disagreed on whether all concepts are derived from experience and whether humans can have any substantive a priori knowledge, a priori knowledge of the physical world, or a priori metaphysical knowledge.[2] The early modern period came to a close, so the narrative claims, once Immanuel Kant, who was neither an empiricist nor a rationalist, combined the insights of both movements in his new Critical philosophy. In so doing, Kant inaugurated the new eras of German idealism and late modern philosophy.

This chapter focuses on Kant's relation to that standard narrative. His *Critique of Pure Reason*, first published in 1781, contrasts empiricism with dogmatism (A466/B494) and empiricists with noologists (A854/B882). The second and third *Critiques*, published, respectively, in 1788 and 1790, reiterate those distinctions, but they replace the term 'noologist' with 'rationalist'. To our knowledge, they are the first published works that explicitly contrast the terms 'empiricism' and 'rationalism'. This chapter has two aims. On the one hand, it identifies Immanuel Kant's contributions to the genesis of the standard narrative. On the other hand, it argues that Kant is not directly responsible for those features of the narrative that have made it the target of an increasing number of attacks from the 1980s onwards.[3] Critics of the narrative

[1] See pp. 3–4, 14.

[2] The disagreement has been said to concern substantive knowledge, a priori knowledge of the physical world (S. Brown 1996b, p. 10; Nickles 2005), knowledge of a mind-independent reality (Hatfield 1990, p. 279), metaphysical knowledge (Priest 2007, p. 5), or knowledge of fact (Schwartz 1999).

[3] Two influential attacks on the narrative are Norton 1981 and Loeb 1981. For an earlier criticism, see Gentile 1966, pp. 59–61.

hold that histories of philosophy revolving around the standard narrative have three biases – three biases for which, as we note below, Kant is often blamed.

The epistemological bias. Since disputes regarding a priori knowledge belong to epistemology, the RED is usually regarded as an epistemological distinction.[4] Accordingly, histories of early modern philosophy based on the RED tend to assume that the core of early modern philosophy lies in the conflict between the 'competing and mutually exclusive epistemologies' of 'rationalism and empiricism'.[5] They typically interpret many of the central doctrines, developments, and disputes of the period in the light of philosophers' commitment to empiricist or rationalist epistemologies. As a result, they have been criticised for:

- misinterpreting those disputes between so-called empiricists and rationalists that derived from divergences on ontological issues, rather than epistemology;[6]
- subordinating the ethics and aesthetics of early modern philosophers to their epistemology, even when they were independent from epistemological matters;[7]
- marginalising political philosophy because of its independence from epistemology.[8]

An author has the epistemological bias if they interpret most of (those that they identify as) the central philosophical doctrines, developments, and disputes of the early modern period in the light of philosophers' commitment to empiricism or rationalism.

The Kantian bias. Histories of early modern philosophy based on the RED tend to portray Kant as the first author who uncovered the limits of empiricism and rationalism, rejected their mistakes, and incorporated their correct insights within his Critical philosophy.[9] This interpretation relies on the view that Kant's Critical philosophy is a superior alternative to empiricism and rationalism – not just a superior empiricist or rationalist alternative to *earlier forms* of empiricism and

[4] For example, by Ryle 2005 [1960], p. 118; Wolterstorff 1999; Nickles 2005, p. 664; Markie 2021, §1; *contra*: Kreimendahl 1998.

[5] Gaukroger 2010, p. 156. See Haakonssen 2006b, p. 6.

[6] For instance, as Engfer (1996, p. 235) has noted, interpretations of the dispute between Locke and Leibniz in the light of the RED tend to obscure the fact that, 'when Leibniz attacks Locke in the *New Essays*, he does not attack him primarily as an empiricist, but as a materialist' who, along with Newton, is responsible for the decline of natural religion in England. For examples of how the focus on epistemology influences Tennemann's history of early modern philosophy, see Section 9.4. See also Engfer 1996, pp. 112, 292; Buckle 1999, pp. 1–2. Markie (2021, §1.2), among others, has noted that 'the rationalist/empiricist classification ... encourages us to expect the philosophers on each side of the divide to have common research programs in areas beyond epistemology'.

[7] Haakonssen 2006b, p. 14.

[8] Haakonssen 2006b, p. 14. For a related criticism, see I. Hunter 2001, pp. 1–29.

[9] For an early example, see Tennemann 1798–1819, discussed in Chapter 9. For a recent example, see Cuneo and van Woudenberg 2004, p. 1.

rationalism, but a superior alternative to empiricism and rationalism as such. In order to have the Kantian bias, one must endorse this view.

The classificatory bias. Typically, histories of philosophy based on the RED classify most early modern philosophers prior to Kant into either the empiricist or the rationalist camps. These classifications have proven far from convincing. Some claim that canonical empiricists were in fact rationalists, or vice versa.[10] Others claim that canonical empiricists or rationalists were both empiricists and rationalists, neither empiricists nor rationalists, or occupied an intermediate position between the two camps.[11] Yet others note that the traditional classifications invite historians to assume that 'successive figures apply the school's basic (rationalist or empiricist) principles with increasing rigor to a common body of problems, ultimately carrying them through to their "logical conclusion"' (Loeb 1981, pp. 13–14).[12] This led historians to overestimate the degree of continuity within each camp;[13] underestimate the manifold positive influences of earlier empiricists on later rationalists and earlier rationalists on later empiricists;[14] and overlook the affinities between the views of empiricists like Berkeley and Hume and those of rationalists like Malebranche and Leibniz.[15] Thus, standard histories of early modern philosophy have a classificatory bias that consists in classifying most or all early modern authors as empiricists or rationalists.

The three biases combine to create an overarching narrative of early modern philosophy centred on the antinomy of empiricism and rationalism. The classificatory bias maps the rationalist thesis and the empiricist antithesis onto the history of early modern thought. The epistemological bias provides the content of the classificatory dichotomy by interpreting the central conflict between empiricism and rationalism as a conflict between competing epistemologies. The Kantian bias provides the epilogue of the narrative and the solution of the

[10] See, among others, Laporte (1950, p. 477) and D. Clarke (1982, pp. 118, 121, 122, 201, 204) on Descartes' empiricism; Rescher (1979, p. 124; 1980) on Leibniz's empiricism; Aaron (1971, pp. 331–51) on Locke's rationalism; Bracken (1974, pp. 15–17, 259) and Loeb (1981, pp. 59–62, 350–1) on Berkeley's rationalism.

[11] For example, Tonelli 1959, p. 19; Watson 1993, p. 97; Engfer 1996; Antognazza 2004, p. 474; and, on Descartes, Garber 2001, p. 110.

[12] For instance, Berkeley's denial of the existence of material substances and Hume's scepticism on spiritual substances are said to derive from Locke's doctrine of the 'veil of perception'. Spinoza's monism and Leibniz's pre-established harmony are seen as attempts to overcome the difficulties raised by Descartes' mind–body dualism.

[13] For instance, considering Leibniz's pre-established harmony as a response to Descartes' mind–body dualism has led some historians to overlook the broader implications of Leibniz's doctrine, which go well beyond issues concerning the relation between mind and body.

[14] For example, Descartes' influence on Locke (Loeb 1981) and Berkeley (Bracken 1974, e.g., pp. 15–18); Malebranche's influence on Berkeley (Luce 1934; Loeb 1981, pp. 59–62, 350–1); and Leibniz's influence on Hume (Engfer 1996, pp. 329–32).

[15] See, for example, Ishiguro 1986; Daniel 2007.

antinomy by portraying Kant's philosophy as a synthesis of empiricism and rationalism.

It is often claimed that the culprit here was Immanuel Kant. As for the classificatory bias, Kant is said to have 'argued, in the *Critique of Pure Reason*, that empiricism and rationalism represent two comprehensive options, and that the philosophers of his day were drawn, respectively, to one or other of them' (Scruton 1994, p. 30).[16] 'This was the easiest way to describe the development of philosophy in the two centuries prior to Kant in the light of his own problem' (Gentile 1966, p. 60):[17] namely, an epistemological problem. Kant allegedly had the epistemological bias because he reduced 'the history of modern philosophy to an epistemological clash between rationalism and empiricism' (Haakonssen 2006b, p. 18).[18] He did this in order to 'argue for a third option, his own, which incorporated, as he saw it, what was true in both [empiricism and rationalism], while avoiding their errors' (Scruton 1994, p. 30).[19] 'In this regard, it is certainly correct to say that Kant fully consciously employs the strategic rule of *divide et impera* in determining the philosophical position of the *Critique of Pure Reason*' (Engfer 1996, p. 357, see also p. 411). He exhibited the Kantian bias by recommending his own philosophy as the '"true middle course" between the self-revealing one-sidedness of empiricism and rationalism' (Engfer 1996, p. 357).[20]

This chapter provides a more nuanced account of Kant's contribution to the development of the standard narrative. We argue that Kant is not directly responsible for the three biases of the standard historiography. In fact, Kant did not have any of the three biases. He did not classify most or all early modern philosophers as empiricists or rationalists. He did not regard his philosophy as an alternative to empiricism and rationalism as such, but rather, as a form of rationalism. And he did not interpret most of the main philosophical doctrines, developments, and disputes of the early modern period in the light of philosophers' commitment to empiricism or rationalism. Nevertheless, Kant made three indirect contributions to the development of the standard narrative:

(*a*) He formulated the notions of empiricism and rationalism that are at the basis of the standard narrative, and he employed them in his sketches of the history of modern philosophy.

[16] In a similar vein, Gaukroger (2010, p. 156) mentions 'the Kantian interest of providing a genealogy of all earlier philosophy whereby certain problems irresoluble in earlier systems can be seen to be finally and definitively resolved only by adopting the Kantian project'.

[17] See also Rorty 1979, p. 148.

[18] Additionally, Kant has been said to have been 'impermissibly reductive in his attempt to present empiricism as a purely epistemological position' (Waldow 2010, p. 307).

[19] See Schmauke 2002, p. 106; Holzhey and Mudroch 2005, pp. 111–12.

[20] See Papadimitriou 1981, pp. 39, 41; I. Hunter 2007, pp. 592–4.

(*b*) He outlined, most notably in the antinomies, a dialectical pattern of argument that would inform the standard narrative.
(*c*) He promoted a way of writing histories of philosophy which, once combined with (*a*) and (*b*), would give rise to the biases of the standard narrative.

The chapter is divided into seven sections. Section 8.1 outlines Kant's notions of empiricism and its rivals. Section 8.2 examines the role of the RED in Kant's sketches of the history of philosophy. In Sections 8.3 to 8.5, we argue that Kant is not directly responsible for the three biases of the standard narrative. After a brief excursus, in the final section we identify Kant's contributions to the development of the standard narrative.

8.1 Three Empiricisms and Their Rivals

Kant's Critical works contain three different notions of empiricism. They all relate to sensory experience, albeit in different ways. The first, which we call *immodest empiricism*, is the denial that non-sensible objects exist. The second, *modest empiricism*, is the denial that we can experience certain items, regardless of whether they actually exist. The third, *history-empiricism*, is the denial that we can either form concepts or justify synthetic judgements a priori, independently from experience.[21]

The antinomies: Immodest Empiricism, Modest Empiricism, and Dogmatism. Immodest and modest empiricism are introduced in the Antinomy chapter of the *Critique of Pure Reason*. As is well known, the antinomies are four pairs of incompatible sentences (theses and antitheses) concerning features of the world: having a beginning in time or existing since eternity; having spatial boundaries or being infinitely large, having simple parts or being infinitely divisible;[22] being only governed by laws of nature or also by free causes; and finally, including or excluding a necessary being. For each thesis and antithesis, there are philosophers prior to Kant who thought that they could prove it.[23] Kant himself provides a proof of each thesis and antithesis. Hence, the antinomies are not only conflicts between incompatible metaphysical claims, they are also conflicts between antithetic metaphysical arguments. Adjudicating these conflicts is an important step for the execution of Kant's project in the

[21] For an analysis of Kant's use of the RED, see Engfer 1996, pp. 19–26, 410–17. For some remarks, see W. H. Walsh 1981, pp. 387–91.
[22] The second antinomy (A434/B462, A436/B463) ascribes those properties to things in the world. We ascribe them to the world because Kant holds that the antinomies concern the idea of the world as a whole. If everything in the world has simple parts or is infinitely divisible, the world as a whole will also be as such.
[23] See, for instance, Heimsoeth 1960a, 1960b on the history of the problems raised by the first two antinomies.

first *Critique*: establishing reason's 'rightful claims' (Axi) in the field of metaphysics by identifying the conditions, extension, and limits of a priori knowledge.

Commenting on the antinomies, Kant writes that, because of their 'essential distinguishing mark', the theses can be called 'the *dogmatism* of pure reason', whereas a 'principle of pure *empiricism*' can be found in 'the assertions of the antithesis' of each antinomy.[24] Unfortunately, the Antinomy chapter never states what the 'distinguishing mark' of dogmatism and the 'principle of pure *empiricism*' might be. To clarify this, it is helpful to recall how the theses diverge from the antitheses. They diverge on whether certain items exist. The theses are distinctive of dogmatism and assert the existence of a beginning of the world, spatial boundaries of the world, indivisible objects, contra-causal free actions, and a necessary being. The antitheses are distinctive of empiricism and deny their existence. This is because empiricists take the possibility of having sensory experience of an item as a necessary condition for its existence (A468/B496). According to empiricists,

[**Immodest Empiricism**] only sensible objects exist.

The reason for the charge of immodesty will become clear in what follows. In Kant's view, humans could never have sensory experience of the items the antinomies are about: a moment prior to which the world did not exist, spatial boundaries of the world, objects without parts, and so on. Humans cannot infer the existence of those items on the basis of experience either. They are not sensible objects, therefore empiricists deny their existence. For instance, empiricists deny the existence of simple objects because they 'can never be exhibited *in concreto* either to sense or imagination' (A469/B497). They reject contra-causal freedom because it 'cannot be encountered in any experience, and hence is an empty thought-entity' (A447/B475), and so on.

Against empiricists, dogmatists claim that

[**Antinomy-Dogmatism**] there are non-sensible objects.

In their view, sound deductive arguments prove the existence of non-sensible, 'intellectual starting points' of the world (A466/B494): a beginning of the world, indivisible atoms, contra-causal freedom, and so on. Kant's use of the term 'dogmatism' to refer to this position is more specific than Kant's broad notion of dogmatism. Dogmatism in the broad sense is

[24] A465–6/B493–4, trans. modified. This is the first occurrence of the term 'empiricism' in a work published by Kant. Before the *Critique of Pure Reason*, Kant mentions empiricism and rationalism in *Refl.* 2571 (*c.* 1772–8), 16: 424; *Refl.* 4100 (*c.* 1769–78), 17: 415; *Refl.* 4953 (*c.* 1776–8), 18: 39–40; *Refl.* 7217 (*c.* 1776–89?), 19: 288.

[Broad Dogmatism] the presumption of being able to acquire metaphysical knowledge by means of a priori reasoning, without a preliminary inquiry into whether metaphysical knowledge lies within human grasp.[25]

Not only the supporters of the theses, but also the empiricists who endorse the antitheses are dogmatists in the broad sense. In fact, Kant qualifies the empiricism of the antinomies as dogmatic (A471/B499, quoted below).

As is well known, Kant rejects this dogmatic form of empiricism. In his view, empiricists should not claim that the world is eternal, that it is infinitely extended, and that all bodies are divisible.[26] They should only claim that we can continue indefinitely in discovering new regions of the world, identifying earlier causes of past events, and dividing each body into increasingly smaller parts (A517–27/B545–55). Empiricists should endorse a modest form of empiricism:

[Modest Empiricism] 'in the empirical regress there can be encountered *no experience of an absolute boundary*, and hence no experience of a condition as one that is *absolutely unconditioned empirically*'. (A517/B545)

This empiricism is modest because it only licenses claims on what we can experience, and not on what exists or does not exist beyond the bounds of experience. Modest empiricism is as consistent with dogmatism and the positive claims of the theses as it is with immodest empiricism and the negative claims of the antitheses.

The consistency of modest empiricism with the theses is important to Kant because his moral philosophy leads him to endorse the theses of the third and fourth antinomy.[27] However, Kant criticises the dogmatists' attempts to prove the theses within the realm of theoretical philosophy. This is an immodest, dogmatic pretension that surpasses the boundaries of our possible theoretical knowledge. The supporters of the antitheses have an equally dogmatic pretension. Since they deny 'whatever lies beyond the sphere of . . . intuitive cognitions', they make 'the same mistake of immodesty [as dogmatists], which is all the more blamable here, because it causes an irreparable disadvantage to the practical interests of reason' (A471/B499).

[25] See Bxxxv; *Metaphysik* K_2, 28: 710; *Metaphysik* K_3, 29: 955.

[26] We only focus on the first two antinomies for the sake of brevity. For Kant, no inference to the best explanation or analogical reasoning allows us to determine whether unobservable, indivisible atoms exist.

[27] In Kant's view, the existence of moral laws entails that humans are free, that they have an immortal soul, and that they will be punished or rewarded for their actions in the afterlife (*KpV*, 5: 48–9, 122–32). This must be the case even if we are unable to single out any free action in our natural philosophical inquiries. Therefore, empiricists should not deny the existence of freedom, as they do when they endorse the antithesis of the third antinomy. Nor should they deny the existence of an absolutely necessary being, as they do when they endorse the antithesis of the fourth antinomy.

This reference to practical interests points to the concerns that induce Kant to favour modest empiricism. The theses of the antinomies express

> a certain *practical interest*, in which every well-disposed person, once he understands its true advantage to him, heartily shares. That the world has a beginning, that my thinking self is of a simple and therefore incorruptible nature, that this self is likewise free and elevated above natural compulsion in its voluntary actions, and finally, that the whole order of things constituting the world descends from an original being, from which it borrows all its unity and purposive connectedness – these are so many cornerstones of morality and religion. The antithesis robs us of all these supports, or at least seems to rob us of them. (A466/B494)

Modest empiricism, being consistent with the theses, is in line with our practical interests.

The History of Pure Reason: Empiricism versus Noologism. The third notion of empiricism, besides modest and immodest empiricism, can be found in the last section of the first *Critique*, entitled The History of Pure Reason. Despite its title, that section does not provide a history of metaphysics or a priori speculation. It only outlines three 'difference[s] of the ideas which occasioned the chief revolutions' in metaphysics (A853/B881). They are the distinctions between sensual philosophers and intellectual philosophers, empiricists and noologists,[28] and finally, philosophers employing a naturalistic method and those employing a scientific method. The second distinction introduces a new notion of empiricism and its opposite (here called noologism).

Philosophers can be empiricists or noologists '*with regard to the origin* of pure cognitions of reason [*reine Vernunfterkenntnisse*]' (A854/B882). Empiricists claim that those cognitions 'are derived from experience'. Noologists claim that, 'independent from' experience, pure cognitions of reason 'have their source in reason' (A854/B882). The cognitions that Kant is referring to are concepts and judgements. Empiricists 'take all concepts of the understanding from experience' (*Metaphysik Mrongovius*, 29: 763) and hold that no synthetic judgements can have an a priori justification. Kant's proof that such judgements exist makes

[28] This distinction is roughly equivalent to the distinction between immodest empiricism and antinomy-dogmatism. Like immodest empiricists, sensual philosophers 'accepted only sensible *objects*' (A854/B882), claiming 'that reality is in the objects of the senses alone, and that everything else is imagination' (A853/B881). Intellectual philosophers, 'on the contrary, said that in the senses there is nothing but semblance, and that only the understanding cognises that which is true' (A854/B882). In their view, 'the true objects' are 'merely *intelligible*' (A854/B882). Like the dogmatists of the antinomies, intellectual philosophers admit the existence of merely intelligible, non-sensible objects. Their additional claim that these objects are the only true objects does not mean that no sensible objects exist. It means that sensible objects have a lower degree of reality than non-sensible objects. On the doctrine of degrees of reality, see Huenemann 2008, pp. 9–10, 66, 130–2.

empiricism 'completely untenable' (*Fort.*, 20: 275). In synthesis, the empiricists of the History of Pure Reason claim that

[History-Empiricism] all concepts are formed a posteriori[29] and all synthetic judgements can only be justified a posteriori.

By contrast, noologists hold that

[Noologism] some concepts are not formed a posteriori and some synthetic judgements are justified a priori.

Kant uses the term 'rationalism' from the late 1780s onwards to designate noologism, that is, the admission of non-empirical concepts and substantive a priori truths. For instance, Kant's unfinished manuscript on the *Progress of Metaphysics* states that an affirmative answer to the question as to whether all cognition [*alle Erkenntniß*] must 'be derived solely from experience ... would inaugurate the empiricism of transcendental philosophy, and a negative one the rationalism [not 'noologism'] of the same' (*Fort.*, 20: 275).[30] Thus, Kant identifies the RED with the distinction between empiricism and noologism that he first drew in the History of Pure Reason. Unlike the distinction between immodest empiricism and dogmatism, the distinction between empiricism and noologism concerns the existence of empirical concepts and a priori knowledge. As we argue in the next chapter, the first Kantian historians of philosophy distinguished between empiricism and rationalism with regard to those two issues.[31] Recent criticisms of the RED have led to a proliferation of definitions of empiricism and rationalism.[32] Yet, even now, empiricists and rationalists are typically taken to disagree on the existence of non-empirical concepts and substantive a priori knowledge.[33]

8.2 Empiricism and Rationalism in Kant's History of Philosophy

Kant was no professional historian of philosophy. He held that a history of philosophy should be a part of his Critical system (A852/B880), but he never wrote one.[34] He taught nearly every philosophical discipline that was

[29] This means that their content depends on which sensations the beings possessing those concepts have had, unlike the content of inborn and endogenous concepts. The latter are generated by the human mind in the course of one's life, but their content does not depend on what particular sensations one has had. According to Kant, this is the case for concepts such as those of substance and cause. See *Entd.*, 8: 221; *Metaphysik. K*$_3$, 29: 952; Oberhausen 1997.

[30] See also *KpV*, 5: 71; *KU*, 5: 346. There is also a theological use of the term 'rationalism' in Kant's corpus, which we do not discuss.

[31] For example, Reinhold 2011 [1791], pp. 44, 132, and Tennemann 1798–1819, vols. 10–11.

[32] See the texts quoted at p. 3, n. 8.

[33] See, for example, Woolhouse 1988, p. 2; Wolterstorff 1999; Priest 2007, pp. 5–7.

[34] He once considered the best person for that task to be one of his correspondents, Karl Morgensten (*Briefwechsel*, 12: 36 [1795]). Kant made extensive notes for a prize essay on the history of progress in metaphysics, but he never completed it.

institutionalised at the time, in addition to other subjects like mathematics, but he never lectured on the history of philosophy. Nevertheless, Kant provided introductions to the history of logic and philosophy at the beginning of his courses on logic and on the philosophical encyclopaedia. He did this deliberately, as there was no obligation for philosophy teachers to provide such historical overviews in late eighteenth-century Prussia.[35] He also interspersed his lectures with historical remarks, as can be seen from the transcripts. Historical comments are scattered across his manuscript notes, letters, and published works, including the first and last pages of the *Critique of Pure Reason* (Avii–xii, A852–6/B880–4). By combining these sources, it is possible to gain a fairly precise understanding of the role that empiricism and rationalism play within Kant's views on the history of early modern philosophy.[36]

Kant employs the notions of empiricism and rationalism in his sketches of the history of both ancient and modern philosophy. Some ancient philosophers, like Socrates, focused only on practical philosophy. Those who had a theoretical philosophy were either dogmatists or sceptics.[37] Unsurprisingly, Kant identifies a central problem of his own philosophy as a main source of disputes between dogmatists: what is the origin of our intellectual concepts?[38] Depending on how philosophers answered that question, Kant divides them into philosophers '*ex principiis sensitivis*' and philosophers '*ex principiis rationalibus*' (*Refl.* 1636 [1760–72?], 16: 60), that is, empiricists and noologists (A854/B882) or rationalists. Some lecture transcripts differentiate not two, but three positions: mysticism, empiricism, and rationalism.[39] These classifications are summarised in Figure 8.1.

[35] Some did (e.g., Feder 1774); others did not (e.g., Meier 1924 [1752]).

[36] To reconstruct Kant's views, we must rely to a significant extent on materials that Kant never intended to be published, especially manuscript notes (*Reflexionen*) and lecture transcripts. These materials must be used with caution (Conrad 1994, pp. 43–65). In what follows, we take materials from the 1770s into account, in addition to texts from the Critical period narrowly understood (1781–1804). The accounts of the history of philosophy in Kant's texts from the 1770s are informative and mostly consistent with his later views. For overviews of Kant's historiographical claims, see Caygill 1995, pp. 225–8; Givone 1972, pp. 135–71. For an analysis, see Micheli 1982, pp. 57–214.

[37] Some texts on ancient philosophy first distinguish between practical and theoretical philosophers. Then they classify theoretical philosophers into dogmatists and sceptics. See *Refl.* 1636 (*c.* 1760–72?), 16: 60; *Logik Philippi*, 24: 327–31. Other passages classify ancient philosophers as such into dogmatists and sceptics, without first distinguishing between theoretical and practical philosophers. See, for example, an addition (1776–89) to *Refl.* 1635, 16: 59; *Logik Blomberg*, 24: 207.

[38] *Metaphysik Volckmann*, 28: 373; *Metaphysik Mrongovius*, 29: 759.

[39] *Metaphysik Volckmann*, 28: 373; *Metaphysik Dohna*, 28: 619; *Metaphysik* K_3, 29: 953; compare *KpV*, 5: 70–1, on practical philosophy. According to *Metaphysik Mrongovius*, 29: 761, mysticism is not a third position, beside those of empiricists and rationalists. Instead,

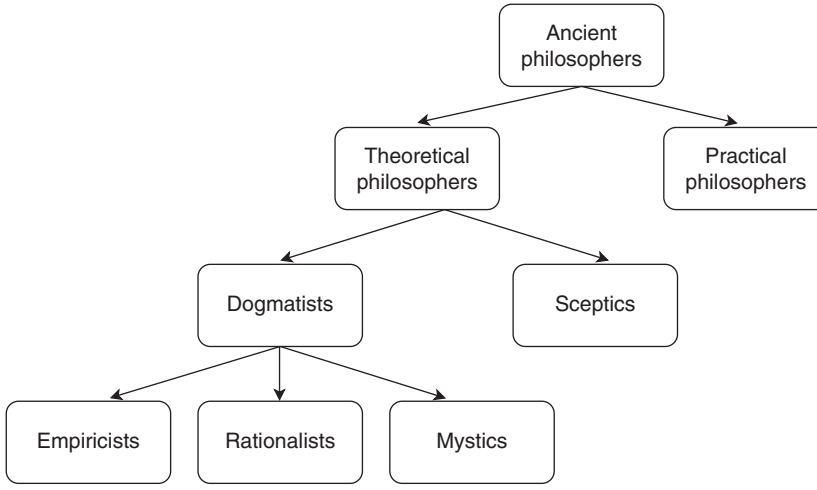


Figure 8.1 A classification of ancient philosophers in Kant's lecture transcripts

According to *mystical philosophers*, our concepts do not differ in kind from perceptions or, to use Kant's term, intuitions. Concepts are intuitions stored in memory. The intellect, and not the senses, generated those intuitions. Our intellect has a quasi-perceptual capacity to apprehend concepts, in the same way in which our senses have the capacity to apprehend sensory stimuli. The paradigmatic example of this view is Plato. Kant's lecture transcripts portray his doctrine of reminiscence as a sort of Malebranchean vision in God. During an earlier life, we had 'an intuition of God from which we derived all remaining ideas, [and] of which we now have only weak memories, that occur to us on the occasion of sensible appearances. Now we no longer have this because our soul is locked up in our body as though in a prison' (*Metaphysik Mrongovius*, 29: 760).[40] Our concepts are faded copies of the intuitions that we had in that previous life, when our soul was looking directly into God's mind.[41]

Unlike Plato, *rationalist philosophers* differentiate concepts from intuitions, but unlike Aristotle, they do not take intellectual concepts to have empirical origin. This view was not instantiated in antiquity. It can only be found among the moderns, starting with Leibniz. He 'believed in innate ideas', but unlike Plato, he

both empiricists and rationalists can be mystic or non-mystic. They are mystic if they hold that concepts are of the same kind as intuitions, non-mystic if they do not.

[40] See also *Metaphysik* K_3, 29: 953–4.

[41] See *Refl.* 6050–1 (1776–89?), 16: 434–5, 437; *Logik Philippi*, 24: 327; *Metaphysik* L_1, 28: 232; *Metaphysik* K_3, 29: 953; *Vorlesung philosophische Enziklopädie*, 29: 15–16. The *Metaphysik Volckmann* states that Plato was not a mystic (28: 373, lines 3–6) and later that he was a mystic (line 17). Plato's mysticism is also mentioned in Kant's published works (e.g., A854/B882). However, it is featured more prominently in the lecture transcripts.

'left the mystical aside' by distinguishing ideas from intellectual intuitions (*Metaphysik Mrongovius*, 29: 761, 763).[42]

Empiricists, too, distinguish concepts from intuitions. They claim that all concepts are acquired a posteriori on the basis of sensations. The paradigmatic examples of this view are Aristotle and Epicurus in antiquity, Locke and Hume in modern times. Aristotle's intellectual concepts are similar to Locke's concepts of reflection. 'Aristotle says: the concepts of the understanding are not innate but rather acquired, we obtained them on the occasion of experience, when we reflect[ed] upon the objects of the senses' (*Metaphysik Mrongovius*, 29: 761).[43] Aristotle and Locke trespassed the boundaries of their professed empiricism when they claimed that 'the existence of God can be proven from experience . . . but since God cannot be an object of experience, how should I come to know his existence? Therefore the system of Locke and Aristotle is inconsistent' (*Metaphysik Volckmann*, 28: 375).[44] Among the ancients, Kant's favourite empiricist is not Aristotle, but Epicurus.[45] He is more consistent than Aristotle because he did not attempt to prove God's existence. In fact, he rejected metaphysics altogether (*Metaphysik von Schön*, 28: 466). 'For metaphysics must rest simply on pure [i.e., non-empirical] concepts of reason, and therefore can never take them from experience' (*Metaphysik K_3*, 29: 953).

In modern times, Hume followed in Epicurus' footsteps as he did not assert the existence of God, human freedom, or the immortality of the soul (*KpV*, 5: 13) and he confined himself to the realm of physics. Within that discipline, Hume endorsed a 'universal empiricism of principles' (*KpV*, 5: 13). A cornerstone of this position is Hume's psychological account of the origin of the notion of cause (*KpV*, 5: 51). This doctrine led to an unwelcome consequence, namely,

> the most rigorous *scepticism* with respect to the whole of natural science (as philosophy). For, on such principles we can never *infer* a consequence from the given determinations of things as existing (since for this the concept of a cause, which contains the necessity of such a connection, would be required) but can only expect, by the rule of imagination, cases similar to preceding ones, though this expectation is never secure however often it is fulfilled. . . . This firmly grounds and makes irrefutable scepticism with respect to inferences rising from effects to causes. (*KpV*, 5: 51–2)

Hume 'did not make empiricism so universal as to include mathematics' (*KpV*, 5: 13).[46] He attempted to preserve its necessity by claiming that

[42] It is hard to reconcile this claim with Kant's view that, for Leibniz, the distinction between sensibility and understanding is gradual, not qualitative (A44/B61).

[43] See also *Logik Philippi*, 24: 327.

[44] In A854–5/B882–3, Kant ascribes to both Aristotle and Locke the view that 'one can prove the existence of God and the immortality of the soul (though both objects lie entirely outside of the bounds of possible experience) just as self-evidently as any mathematical theorem'.

[45] *Metaphysik Volckmann*, 28: 376; see *Metaphysik K_3*, 29: 953; *Logik Philippi*, 24: 328.

[46] Mathematics raised difficulties for Locke's empiricism too. See *Entd.*, 8: 211 n.

mathematical statements are – in Kant's terms – analytic.[47] However, Hume's attempt to preserve the necessity of mathematics failed: 'if one assumes *universal* empiricism of principles, then mathematics will be included' (*KpV*, 5: 13). This is because mathematical statements are synthetic (B14; *Prol.*, 4: 268) and only a priori propositions are necessary.[48] Based on these assumptions, one can only preserve the necessity of mathematics by claiming that mathematical propositions are both synthetic and a priori. If Hume endorsed this view, he would have abandoned empiricism. To be faithful to his professed empiricism, Hume should have acknowledged that it leads 'unavoidably to scepticism even with respect to mathematics and consequently in every *scientific* theoretical use of reason (for this belongs either to philosophy or to mathematics)' (*KpV*, 5: 52). For Kant, the sceptical consequences of Humean empiricism are as unacceptable as the contradictions arising from dogmatism, highlighted in the antinomies. Having ruled out dogmatism as well as scepticism, Kant concludes the History of Pure Reason by claiming that 'the *critical* path alone is still open' (A856/B884, see also Axii).

8.3 The Classificatory Bias

Having surveyed Kant's distinctions between empiricism and its rivals and the role of the RED in Kant's comments on the history of philosophy, we can determine whether Kant has the classificatory bias, the Kantian bias, and the epistemological bias. Kant will have the classificatory bias if he claims that most or all of his early modern predecessors are either empiricists or rationalists.

As we saw in the previous section, Kant classes two early modern philosophers as empiricists: John Locke and David Hume.[49] Kant classes only one early modern philosopher, Gottfried Wilhelm Leibniz, as a rationalist (A854/B882). These classifications are represented in Table 8.1 below (with an addition that is explained in the next section).

There are good reasons to hold that Kant regards other early modern philosophers as rationalists or empiricists, as summarised in Table 8.2 below:

- The *Metaphysik Mrongovius* (29: 761) associates Crusius with Plato and Leibniz. This suggests that Kant takes Crusius to be a rationalist.
- By combining two passages from the second *Critique* (5: 40, 70–1), one can infer that Kant regards Montaigne, Mandeville, and Hutcheson as moral

[47] As the editor of the English translation of *KpV* notes (Gregor 1996, p. 631), Kant's claim can only plausibly apply to Hume's conception of arithmetic, not to his conception of geometry.

[48] See *KpV*, 5: 51: 'necessity can be attributed to a connection only insofar as the connection is cognised *a priori*'.

[49] On Locke, see A854/B882; *Entd.*, 8: 211 n.; *Metaphysik Mrongovius*, 29: 763. On Hume, see *KpV*, 5: 12, 13, 51, 52.

Table 8.1 *Early modern philosophers whom Kant explicitly classes as rationalists or empiricists*

Rationalists	Empiricists
Leibniz	Locke
Kant	Hume

Table 8.2 *Early modern philosophers whom Kant appears to regard as rationalists or empiricists*

	Rationalists	Empiricists
In general	Crusius	
In ethics	Wolff	Montaigne
	Crusius	Mandeville
		Hutcheson
In aesthetics	Baumgarten	
	Meier	

empiricists, Wolff and Crusius as moral rationalists. Moral rationalists judge whether an action is morally good on the basis of its conformity to an a priori law. Moral empiricists judge whether an action is morally good on the basis of its consequences, namely whether it promotes happiness.

- By combining two passages from the third *Critique* (5: 277–8, 346–51), one can infer that Kant would call Edmund Burke an empiricist about beauty. Aesthetic empiricists claim that judgements of taste can only be based on empirical principles. Aesthetic rationalists claim that whether an object is beautiful depends on its conformity with an a priori principle.
- Kant does not mention any aesthetic rationalists in the third *Critique*. However, he criticises a form of aesthetic rationalism that assimilates beauty to perfection (*KU*, 5: 347). This was the view of Christian Wolff (1751), Alexander Baumgarten (1750), and Georg Friedrich Meier (1754–9), all authors whom Kant knew well.

In order to extend Kant's list of empiricists and rationalists, it is tempting to identify the empiricists and noologists of the History of Pure Reason with the immodest empiricists and dogmatists of the antinomies. This temptation should be resisted for two reasons. In the first place, the distinctions do not

map onto each other.[50] Immodest empiricists can be noologists. They can claim, as immodest empiricists, that all objects are sensible, and as noologists, that we know some of their features a priori. For instance, we may know a priori that all objects are subjected to the causal law. Modest empiricists can be noologists too. As we argue in the next section, Kant himself endorses not only modest empiricism, but also noologism.

In the second place, the antinomies do not introduce any clear-cut distinction among Kant's predecessors. For instance, if we look at the first antinomy, we find the Newtonian Samuel Clarke endorsing the argument for the thesis and the rationalist Leibniz endorsing the argument for the antithesis (Allison 2004, p. 366). This is the opposite of what one would expect, because Kant ascribes the theses to dogmatists and the antitheses to empiricists. If we look at the second antinomy, we find both Leibniz *and* Clarke endorsing key assumptions at the basis of the proofs of the thesis and antithesis (Grier 2001, pp. 205–9). Kant reserves the term 'rationalism' for the noologism of the History of Pure Reason, rather than antinomy-dogmatism. It is best to follow Kant's policy and avoid conflating the RED, introduced in the History of Pure Reason, with the distinction between immodest empiricists and antinomy-dogmatists.

Tables 8.1 and 8.2 fail to mention many prominent early modern authors. These include canonical empiricists like Bacon (to whom Kant dedicated the *Critique of Pure Reason*), Boyle, Gassendi, and Berkeley and canonical rationalists like Descartes and Malebranche, in addition to Hobbes, d'Alembert, La Mettrie, Helvétius, Reid, Oswald, Beattie, and Priestley. Kant mentions them all, but he categorises none of them as an empiricist or a rationalist.[51] Since so many authors escape the RED in Kant's texts, Kant is hardly responsible for introducing the classificatory bias within philosophical historiography.

We are not claiming that, given Kant's statements, it would be inconsistent for him to have the classificatory bias. Nor are we denying that, when post-Kantian historians such as Tennemann carried out extensive classifications of early modern authors as being either empiricists or rationalists, they were acting in a broadly Kantian spirit. Kant often looks at earlier philosophers as

[50] Heimsoeth (1966–71, 4, p. 824 n.) is careful to distinguish the immodest empiricism of the antinomies from the empiricism of the History of Pure Reason.

[51] He regards Berkeley and Descartes as idealists (B274; *Prol.*, 4: 293, 336, 375; *Refl.* 6311 [1790], 18: 610; *pace* Holzhey and Mudroch 2005, p. 112). His accounts of the history of philosophy, logic, physics, and ethics mention Bacon (e.g., *Logik Busolt*, 24: 613; *Danziger Physik*, 29: 103), Boyle (e.g., *Danziger Physik*, 29: 107), Gassendi (e.g., *Danziger Physik*, 29: 107), Malebranche (e.g., *Logik Pölitz*, 24: 509), Newton (e.g., *KU*, 5: 308–400), d'Alembert (e.g., *Opus postumum*, 21: 239, 22: 544), La Mettrie, and Helvétius (*Praktische Philosophie Powalski*, 27: 100). Kant also mentions Hobbes (e.g., A752/B780), Spinoza (e.g., *KU*, 5: 393), Reid, Beattie, Oswald, and Priestley (all in *Prol.*, 4: 258), albeit not in his histories of logic or philosophy.

examples of ideal types like empiricism or rationalism, rather than as exponents of actual historical movements. The classificatory bias that can be found in Tennemann and others derives from an extensive application of Kant's typological approach to the history of philosophy.[52] Nevertheless, having the classificatory bias means classifying most or all early modern authors as empiricists or rationalists, and such classifications cannot be found in Kant's writings.

8.4 The Kantian Bias

According to several scholars, the only early modern philosopher that Kant classes neither as an empiricist nor as a rationalist is himself. By placing himself over and above empiricism and rationalism, Kant would be the source of the Kantian bias.

Kant's predilection for tripartitions is well known. The very nature of transcendental philosophy, he tells us at one point (*KU*, 5: 197 n.), makes it inevitable that almost all its subdivisions are tripartite. Kant had a lifelong tendency to single out apparently insoluble contrasts between pairs of philosophical theories, only in order to put forward his own views as superior to both alternatives: Newtonian dynamics and Leibnizian monadology in physics, dogmatism and scepticism concerning knowledge, Epicureanism and Stoicism in ethics, realism and subjectivism about beauty. The antinomies of the first *Critique* provide the most famous example of this strategy, while introducing the distinction between empiricism and dogmatism. It is natural to expect that Kant applied his strategy of *divide et impera* to position his own philosophy over and above empiricism and rationalism.[53]

Contrary to this expectation, Kant's texts never state that his philosophy is an alternative to empiricism and rationalism as such. There are plenty of occasions on which Kant could have made this claim. For instance, Kant makes clear in the Annotation to the Amphiboly that he takes his philosophy to be superior to those of Locke, who '*sensitivised* the concepts of understanding', and Leibniz, who '*intellectualised* the appearances' (A271/B327). Since Kant classes Locke as an empiricist and Leibniz as a rationalist, the passage indicates that Kant takes his philosophy to be superior to their particular brands of empiricism and rationalism. Yet neither on this occasion nor on other occasions does Kant add that his philosophy is superior to empiricism and rationalism as such. On the contrary, while he argues in the second *Critique* that his moral philosophy is superior to the moral rationalism of Wolff and Crusius and to the moral empiricism of Montaigne and others, he still characterises his moral philosophy as a kind of rationalism – a '*rationalism* of the capacity of judgement' (*KpV*, 5: 71). Similarly, Kant rejects Burke's empiricism and Wolff's rationalism in aesthetics in the third *Critique*. However, he still endorses 'rationalism of the principle of taste' (*KU*, 5: 347). Kant

[52] See Di Bella 2008, p. 52; Micheli et al. 2015, p. 781.
[53] Engfer 1996, p. 357.

contrasts his own aesthetic rationalism with the rationalism of Wolff, Baumgarten, and Meier by qualifying their rationalism as realist and his as idealist. He portrays his idealist aesthetic rationalism as superior to aesthetic empiricism on the one hand and realist aesthetic rationalism on the other. However, he still characterises his position as a form of *rationalism* instead of characterising it, as Kant scholars often do,[54] as a Critical alternative to aesthetic empiricism and rationalism as such.

Did Kant regard his theoretical philosophy too, like his ethics and aesthetics, as a form of rationalism? Kant's texts provide three reasons to hold that he did. In the first place, according to the History of Pure Reason, noologists hold that we have 'pure cognitions of reason [*reine Vernunfterkenntnisse*]' which 'have their source in reason', 'independent from' experience (A854/B882). Some of the central arguments of the first *Critique* aim to establish precisely those claims. They argue that some of our concepts – the categories – have a non-empirical origin and that we can know some synthetic judgements to be true a priori. For Kant, these are distinctive views of noologists, that is, rationalists.[55] Kant's characterisation of his own ethics and aesthetics as rationalist, too, is consistent with his definition of rationalism. Kant takes ethics and aesthetics to be based on synthetic a priori principles, and he ascribes a non-empirical origin to the concept of virtue (*Religion*, 6: 183).

In the second place, a passage of the *Progress of Metaphysics*, written in the first half of the 1790s and quoted at p. 242, discusses the possible answers to the question as to whether 'all cognition [*alles Erkenntniß*]' is 'to be derived solely from experience'.[56] The text states that a negative answer inaugurates 'the rationalism' of transcendental philosophy. Kant had given such a negative answer a few years earlier, at the beginning of the 1787 introduction to the *Critique of Pure Reason*: 'As far as time is concerned, then, no cognition in us precedes experience. . . . But although all our cognition commences *with* experience, yet it does not on that

[54] For example, Zuckert 2007, p. 177.

[55] Kant could not call himself a rationalist if he regarded the claim that we have *innate* concepts as constitutive of rationalism, as scholars sometimes do (e.g., Schwartz 1999, p. 704). Kant declares that he agrees with empiricists that 'all our cognition commences with experience' (B1) and that there are 'absolutely no implanted or innate *representations*' (*Entd.*, 8: 221). Kant only ascribes the claim that we have *pure* (i.e., non-empirical) concepts to rationalists. He takes the categories to be pure, non-empirical concepts because they are acquired through a mental process that, albeit triggered by experience, 'brings them about, *a priori*, out of' our 'cognitive faculty', without relying on any information provided by the senses (*Entd.*, 8: 221). Some Kantian texts (e.g., *De mundi sensibilis atque intelligibilis forma et principiis*, 2: 395; *Metaphysik Dohna*, 28: 619; *Metaphysik* K_3, 29: 951–2) refer to this process as the original or a priori acquisition of the categories, which is parallel to the original acquisition of our representation of space (*Entd.*, 8: 223).

[56] *Fort.*, 20: 275. Without attempting to unpack the nuances of Kant's uses of 'cognition' (*Erkenntnis*), we broadly agree with Karl Ameriks' (2000, p. 44) statement that, in its propositional use, 'unlike the standard English philosophical use of the term "knowledge"', Kant's term *Erkenntnis* 'signifies a "lower" kind of "cognitive state" that involves a grounded or putative truth claim but not necessarily an actual truth'.

account all arise *from* experience' (B1). The Transcendental Aesthetic and Transcendental Analytic of the first *Critique* provide extended arguments for that claim.

Finally, three transcripts of Kant's metaphysics lectures from the first half of the 1790s indicate that Kant, at that time, was endorsing a form of rationalism. The transcript of Kant's third lecture from the Winter Semester 1792/3 outlines his view that concepts such as those of cause and effect are not innate but acquired a priori. After alluding to alternative positions (Epicurus' empiricism and Plato's mysticism), the text states: 'It is rationalism that we seek, in fact, we want to regard our cognitions as acquired *a priori*' (28: 619). The transcript of the next lecture starts by elaborating on the earlier endorsement of rationalism. The text explains that there are two types of rationalism: dogmatic rationalism and Critical rationalism. The latter, 'begins by inquiring into human reason . . . as regards its extension, content and limits' (28: 619). As we know from the *Prolegomena* (4: 261), the philosophy that Kant took to have first determined the extension, content, and limits of human reason is his own Critical philosophy. This suggests that Critical rationalism and Critical philosophy are identical.

The *Metaphysik* K_2, based on lectures from the early 1790s, outlines the same distinction between dogmatic and Critical rationalism and laments that, in the past, 'the critical method of rationalism has never been followed' (28: 710). This rules out the identification of Critical rationalism with any pre-Kantian philosophy. For the *Metaphysik* K_3, based on lectures from 1794/5, rationalism is 'the principle of the possibility to represent cognitions *a priori*' (29: 953). A priori cognitions are either analytic or synthetic. Kant finds the possibility to represent analytic cognitions a priori relatively unproblematic. Instead, the possibility to represent synthetic cognitions a priori is as puzzling as it is vital for the sorts of metaphysics. As Kant states in the *Prolegomena* (4: 278), 'all metaphysicians are . . . solemnly and lawfully suspended from their occupations until such a time as they shall have satisfactorily answered the question: *How are synthetic cognitions* a priori *possible*?' By satisfactorily answering that question, Kant's Critical philosophy provides the foundations of the true metaphysics. Accordingly, the *Metaphysik* K_3 calls Critical rationalism 'the first proposition of all metaphysical truths' (29: 953), confirming the identification of Critical rationalism with Critical philosophy.

Admittedly, the most explicit indications that Kant took his philosophy to be a form of rationalism can be found in lecture notes, which are far less reliable than Kant's own works and must be used with care. However, the passages at stake are from three different transcripts. The approximate dating of the lectures on which the transcripts are based are uncontroversial and can be traced back to a time span of only five years (1790–5),[57] all well within the

[57] See Naragon online, https://users.manchester.edu/Facstaff/SSNaragon/Kant/Notes/notesMetaphysics.htm, archived at https://archive.ph/QniZC

Critical period. The meaning of each passage taken individually is rather clear, and the passages are consistent with one another. They are also consistent with the doctrine of the original acquisition of the categories that is sketched in several texts from 1770 to the 1790s and with statements in the first *Critique*, the *Prolegomena*, and the *Progress of Metaphysics*. As we saw earlier in this section, some of those other statements, too, suggest that Kant took his theoretical philosophy to be a form of rationalism. This is in line with Kant's explicit categorisation of his ethics and aesthetics as rationalist. For all these reasons, we can rely on the collective evidence provided by the lecture transcripts and the other texts to conclude that Kant did take his philosophy to be a form of rationalism.

Of course, Kant took his philosophy to be more than just another form of rationalism. He regarded it as the only true rationalism. As we saw in Section 8.2, he criticised earlier forms of rationalism as much as earlier forms of empiricism. At the same time, he accepted tenets of earlier empiricists and rationalists. For instance, he combined Locke's emphasis on the necessity of sensory input for knowledge acquisition with Leibniz's admission of substantive a priori knowledge. Nevertheless, Kant did not see his combination of the views of earlier empiricists and rationalists as an alternative to empiricism and rationalism as such, but rather, as a higher form of rationalism.

One may question whether Kant was right in viewing his philosophy in that way. Few scholars ever claimed that Kant was indeed a rationalist, with the notable exceptions of some of his first readers (e.g., Selle 1786–7) and Erich Adickes (1897, p. 29). Most regarded Kant's philosophy as a *via media* between empiricism and rationalism that is neither empiricist nor rationalist. Others, like Wayne Waxman (2005), take Kant's project to be steeped in Locke's, Berkeley's, and Hume's philosophical tradition.

However things may be, whether Kant had the Kantian bias does not depend on whether his philosophy actually is a form of rationalism, empiricism, or neither. One has the Kantian bias if one holds that Kant's Critical philosophy is a superior alternative to empiricism and rationalism as such, regardless of whether one is correct in holding this. This applies to Kant too. The evidence assembled in this section establishes that he did not take his own philosophy to be an alternative to empiricism and rationalism as such. This is sufficient to conclude that he did not have Kantian bias, regardless of whether he was correct in viewing his own philosophy as a form of rationalism.

8.5 The Epistemological Bias

It is hard to deny that epistemology occupies an important place within Kant's philosophical project. In the theoretical sphere, Kant answers the 'general question' as to the possibility of metaphysics (*Prol.*, 4: 271) by determining

the possibility, extent, and boundaries of a priori *knowledge*.[58] In the practical sphere, Kant defends the possibility of moral responsibility by relying on the assumption that we cannot *know* whether our actions are free or determined. However, whether Kant had the epistemological bias that is at issue in this chapter does not depend on whether he ascribed an important place to epistemology within his overall philosophical project. It depends on whether he interpreted most of those that he identifies as the central philosophical doctrines, developments, and disputes of the early modern period in the light of philosophers' commitments to empiricism and rationalism.

As we saw in Section 8.2, Kant interprets *some* of Locke's, Hume's, and Leibniz's doctrines in the light of their empiricism and rationalism. These are Locke's and Leibniz's accounts of the origin of concepts, Locke's proof of the existence of God, and Hume's account of the origin of the notion of cause. Kant also suggests that Locke's and Hume's philosophy of mathematics is best assessed in the light of their empiricism.[59] Additionally, Kant interprets *one* early modern development, the development from Locke to Hume, in the light of the notion of empiricism. Finally, he explains the divergence between Locke and Leibniz on the origin of concepts as a divergence between Locke's empiricism and Leibniz's rationalism.

There are several other early modern doctrines and developments that Kant does not interpret in the light of the RED. We will provide examples concerning Bacon, Descartes, and Berkeley. Kant holds that a central development at the roots of early modern thought is the emergence of a new method for natural philosophy based on experiments and observations. Like his contemporaries, Johann Nicolaus Tetens and Christian Garve, Kant praises Bacon for pioneering this new method.[60] Tetens and Garve held that Locke and Hume applied Bacon's method to the study of the human mind.[61] Many authors after Kant would make similar claims, linking Bacon to Locke and Hume in their accounts of early modern empiricism. Unlike them, Kant does not relate Bacon's reliance on observations and experiments to Locke's and Hume's

[58] While the propositional items that Kant qualities as *Erkenntnisse*, in a broad sense, can be either true or false, the synthetic a priori *Erkenntnisse* which Kant takes himself to have established in the first *Critique* are synthetic a priori *truths* and can therefore be referred to as synthetic a priori *knowledge*, rather than just as cognitions. While we do not take a stand on the wider question of whether, in the first *Critique*, Kant is primarily interested in the conditions of possibility of cognition, objective reference, or knowledge, we acknowledge that, if Kant is taken to be primarily interested in cognition or objective reference, he is even less likely to have the epistemological bias than if his focus is on knowledge.

[59] See *KpV*, 5: 13, 52; *Entd.*, 8: 211 n.

[60] See, for example, *Pragmatische Anthropologie*, 7: 223; *Wiener Logik*, 24: 804; *Danziger Physik*, 29: 107.

[61] See Tetens 1913 [1775], pp. 68–9; Garve 1796, pp. 297, 401, 403, 405, 427.

empiricism. Kant's lecture transcripts do not mention Locke or Hume but rather Descartes as a follower of Bacon's new method.[62]

Kant sees Descartes as a source of important early modern doctrines. He often criticises the *cogito* argument, Descartes' view that introspection is more trustworthy than the outer senses, and his version of the ontological argument for the existence of God (e.g., A355, B274–5, A347/B405). From a Kantian standpoint, the *cogito* argument and Descartes' version of the ontological argument could be good examples of the rationalist attempt to establish synthetic claims independently of experience. Yet Kant never includes these or other Cartesian arguments within a history of early modern rationalism. He never groups Descartes, Malebranche, or Spinoza together with Leibniz so as to provide a rationalist counterpart to his account of how Hume's scepticism derives from Locke's empiricism.

Instead of grouping Descartes together with Spinoza and Leibniz, Kant categorises him as an idealist together with Berkeley – another author who, since Kant first replied to the Garve–Feder review in the *Prolegomena*, was important in his eyes, but was never categorised as an empiricist or a rationalist. Kant does not articulate any account of early modern thought based on the evolution of idealism or its contrast with realism.[63] More fundamental to him than idealism and realism, empiricism and rationalism, are the three categories of dogmatism, scepticism, and Critical philosophy or Criticism. The unfinished manuscript on the *Progress of Metaphysics* identifies them repeatedly as the three main stages in the history of metaphysics, and the first *Critique* begins and ends by locating Kant's Critical philosophy with respect to the antagonism between dogmatism and scepticism.[64] Yet he typically describes them in abstract terms, with few or no references to early modern philosophers. He could have easily combined the distinction between dogmatism, scepticism, and Criticism with the distinction between empiricism and rationalism, identifying them as the two varieties of dogmatism that can be found in the early modern period. The distinction between empiricism, rationalism, and scepticism could then have provided a template for a comprehensive account of early modern thought that focuses on epistemological issues.[65] As we will see in Section 9.2, Karl Leonhard Reinhold would provide such an account as early as in 1791. Unlike Reinhold and many

[62] For example, *Wiener Logik*, 24: 804; *Metaphysik* L_2, 28: 539; *Danziger Physik*, 29: 107.

[63] For a sketch of the history of early modern philosophy based on this distinction, see Fischer 1856, Preface.

[64] See *Fort*., 20: 264; Avii–xii, A855–6/B883–4.

[65] Kant occasionally states that dogmatists are either sensual philosophers or intellectual philosophers (e.g., *Logik Philippi*, 24: 327). However, he does not develop any detailed account of early modern thought on the basis of this claim. Jeffrey Edwards (2004, pp. 125–6) calls attention to a Kantian sketch of the history of philosophy in which epistemological issues and the RED are not central (*Refl.* 6050–1 [1776–89?], 16: 434–8).

authors after him, Kant did not provide any such account. He interpreted *some*, but not *most*, of the central philosophical doctrines, developments, and disputes of the early modern period in light of the RED. Not Kant but his followers employed the epistemological dichotomy of empiricism and rationalism as the overarching organising principle for the history of early modern thought.

8.6 Excursus: Empiricism, Rationalism, and Historical Progress

In this regard, there is an important difference between Kant's historiographical comments and the post-Kantian histories of philosophy that give pride of place to the RED. They often claim that, within the empiricist and rationalist groups, 'successive figures apply the school's basic (rationalist or empiricist) principles with increasing rigor to a common body of problems, ultimately carrying them through to their "logical conclusion"' (Loeb 1981, pp. 13–14). For instance, Berkeley's denial of the existence of material substance and Hume's scepticism on the existence of spiritual substances are said to derive from Locke's doctrine of the 'veil of perception'. As one historian put it, 'Hume is Locke made logically consistent. Berkeley went only halfway.'[66]

Kant would acknowledge that there was some progress within the empiricist and rationalist camps. In his view, Leibniz's rationalist theory of concepts is better than Plato's because it abandons mysticism. Hume's universal empiricism is more coherent than Locke's empiricism. However, these advances are modest. Despite the abandonment of Plato's mysticism, Leibniz's rationalism is no less doomed to failure than Plato's.[67] Kant famously states that Hume awoke him from dogmatic slumber (*Prol.*, 4: 260), but he also holds that Locke was ahead of Hume on the way to Criticism. It is Locke and not Hume who gains Kant's approval for being the first Critical philosopher.[68] Having asked whether earlier authors have '*advanced metaphysics even one step*', Kant answers: 'I confess that I have not been able to find . . . that the science has thereby been advanced in the least' (*Prol.*, 4: 367–8).

Leibniz's rationalism, Locke's empiricism, and Hume's scepticism are three examples of reason's 'groping about' before finding the Critical path to the truth. Metaphysics was a battlefield on which 'no combatant has ever gained

That sketch revolves around the notions of fanaticism and dogmatism. The only early modern author that it mentions is Spinoza.

[66] Cushman 1911, p. 175; see also Russell 1945, p. 481.

[67] Kant only defends Leibniz when he portrays him as his own predecessor. He does this to discredit those philosophers, like Eberhard, who appealed to Leibniz's authority to reject Kant's philosophy (*Entd.*, 8: 250). In other contexts, Leibniz is one of Kant's favourite targets (e.g., A44/B61–2; A269–89/B316–46; A602/B630).

[68] See an addition of 1764–78 to *Refl.* 1636 (1760–72?), 16: 60; *Logik Blomberg*, 24: 37; *contra*: *Jäsche Logic*, 9: 32.

the least bit of ground, nor has any been able to base any lasting possession on his victory' (Bxiv–xv). To end this stalemate, Kant brought about a 'change in the way of thinking' (Bxvi) within metaphysics similar to those that took place within mathematics and physics. A 'revolution brought about all at once' (Bxvi) placed them on the 'secure course of a science' (Bvii).

The only substantial progress that Kant contemplates is this instantaneous, revolutionary turning away from the blind alleys of previous philosophies in order to enter the Critical path. Once this revolution has taken place, no further progress is possible: 'a critique of [reason's] own power would put it into a condition of stability, both external and internal, in which it would need neither increase nor decrease, nor even be capable of this' (*Fort*., 20: 264).

8.7 Conclusion: Kant's Contribution to the Standard Narrative of Early Modern Philosophy

In this chapter, we have argued that, although Kant developed the notions of empiricism and rationalism that are at the basis of the standard narrative of early modern philosophy, he did not have the classificatory, Kantian, or epistemological biases that characterise that narrative. Kant did, however, promote a way of writing histories of philosophy from which those biases would flow. He did so by endorsing four tenets.

(*a*) History of philosophy is a philosophical discipline.[69] Kant took the section of the first *Critique* on the history of pure reason to designate 'a place that is left open in the system' of philosophy (A852/B880). This provides 'a secure touchstone for appraising the philosophical content of old and new works in this field; otherwise the unqualified historian and judge assesses the groundless assertions of others through his own, which are equally groundless' (B27, trans. modified).[70] Historians should assess past philosophies from a Kantian point of view.

(*b*) Historians of philosophy should reconstruct the 'natural train of thought through which philosophy had to progressively develop from human reason' (*Briefwechsel*, 12: 36 [1795]). The 'temporal sequence' of dogmatism, scepticism, and Criticism 'is founded in the nature of man's cognitive capacity' (*Fort*., 20: 264). Given the nature of human psychology and certain features of each position (such as the inconsistency of dogmatism), humans have an inclination to embrace dogmatism, discover its flaws,

[69] The lecture programs of the university of Königsberg show that '"Historia Philosophiae" was not considered a philosophical, but rather a historical course' in the 1770s (Pozzo 1998, p. 441; see Oberhausen and Pozzo 1999). There is a vast literature on Kant's conception of the history of philosophy. For a bibliography, see Micheli 2015, pp. 765–8. For a critical discussion of some interpretations, see Kolmer 1998.

[70] *Contra*: Tiedemann 1791–7, 1, p. ix in general terms and 3, p. viii with reference to Kant.

move on to scepticism, be dissatisfied by it, and keep searching until they reach the safe haven of Criticism. Historians of philosophy should show how the temporal sequence of specific systems exemplifies this natural development of the human mind.[71]

(*c*) Given the nature of human psychology, it is unavoidable that humans go through the three stages of dogmatism, scepticism, and Criticism. Historians should make the inevitability of this process apparent. They should show how the 'opinions which have chanced to arise here and there' instantiate 'what should have happened', how reason must necessarily develop itself 'from concepts' (*Fort.*, 20: 343).

(*d*) In line with his tendency to endorse intermediate views between two extremes (p. 249), Kant regards his Critical philosophy as a middle way between the extremes of dogmatism and scepticism. It combines the dogmatists' claim that we can know the external world with the sceptics' claim that we cannot know mind-independent objects. Historians of philosophy should describe this historical movement from the two extremes of dogmatism and scepticism to their higher synthesis in Kant's Critical philosophy.

Although Kant regarded his philosophy as a synthesis of dogmatism and scepticism, he did not regard it as a synthesis of empiricism and rationalism as such. However, he claimed that he avoided the opposite mistakes committed by Locke and Leibniz (A271/B327), whom he regarded, respectively, as an empiricist and a rationalist. He also employed a pattern of argument based on the rejection, unification, and overcoming of dichotomies into a third viewpoint. The standard historiography of early modern philosophy saw the light of day once Reinhold, Tennemann, and others picked up Kant's notions of rationalism and history-empiricism, employed Kant's dialectical pattern of argument to portray his philosophy as a higher synthesis of those movements, and followed Kant's advice by writing philosophical histories of philosophy. Their histories exhibit the inexorable, necessary process (*c*) whereby human reason naturally evolved (*b*) from two unacceptable, extreme positions to Kant's higher (*a*), intermediate (*d*) point of view. In the next chapter, we shall see how Kantian historians developed this narrative by focusing on epistemological issues, classifying most early modern thinkers as empiricists or rationalists, and portraying Kant's philosophy as a synthesis of both movements. Kant did not have these three biases. However, given his indirect influence on the standard historiography, it should not be surprising that it retains a Kantian flavour.

[71] By showing this, historians of philosophy relate the factual level of 'what has happened', 'how philosophizing has been done hitherto, and in what order' (*Fort.*, 20: 340), to an abstract taxonomy of philosophical positions that is drawn from a non-empirical, 'transcendental point of view' (A852/B880).

CHAPTER 9

Reinhold, Tennemann, and the Rise of Empiricism

In the previous chapter, we argued that, although Kant introduced the RED, he did not have the epistemological, classificatory, and Kantian biases that are usually associated with the distinction. He did not regard the RED as a solely epistemological distinction, he did not portray most of his early modern predecessors as either empiricists or rationalists, and he did not place himself over and above empiricism and rationalism. This chapter identifies the source of the traditional historiographical model of early modern philosophy that combines the RED with the epistemological, classificatory, and Kantian biases.

After reconstructing the spread of the notions of empiricism and rationalism in Germany during the 1780s, we argue that the first outline of a history of metaphysics that displays the Kantian, epistemological, and classificatory biases can be found in Karl Leonhard Reinhold's works from the early 1790s.[1] Among the intellectuals who became Kantians after reading Reinhold's works was Wilhelm Gottlieb Tennemann. Tennemann developed Reinhold's historical sketches into a detailed, nuanced, and comprehensive account of seventeenth- and eighteenth-century philosophy that revolves around the RED and displays the three biases of the traditional historiography. In fact, those biases follow naturally from a Kantian outlook on the method of philosophical historiography, which Tennemann spelt out in the preface of his eleven-volume *History of Philosophy* (1798–1819).[2]

[1] As far as we are aware, the only studies that mention Reinhold's role in articulating a historiographical paradigm based on the RED are Engfer 1996 (p. 25), which has gone largely unnoticed in the Anglophone community, and Sperber 2017.

[2] This chapter lends support to Richard Popkin's view that the standard narrative originated in 'the German historians of philosophy of the late eighteenth and early nineteenth century' (Popkin 1959, pp. 544–5; see Hatfield 1990, p. 273; Ehrenberg 1998, p. 306; Piaia 1996, pp. 603–4; Sperber 2017). Popkin (1980, pp. 44–5) mentions Tennemann and Fischer as the sources of the standard historiography. Hochstrasser (2000, p. 216) notes Tennemann's (1816) use of the notion of empiricism and rationalism in his account of early modern philosophy. Other authors have suggested that the standard narrative has its origins in 'Hegelian idealism in Germany and Great Britain in the second half of the nineteenth century' (Loeb 1981, p. 31), especially Kuno Fischer (Gaukroger 2010, p. 155) and Thomas Hill Green (Norton 1981, pp. 331–3; Garrett 2004, p. 49). While Fischer did

Two other authors employed the RED in detailed, multi-volume histories of modern philosophy at the turn of the nineteenth century, shortly before Tennemann. They are Johann Gottlieb Buhle (1796–1804, 1800–5) and Joseph-Marie Degérando (1804).[3] Degérando's *Comparative History of Philosophical Systems*, which Tennemann translated into German, is an eclectic work that displays the influence of Kant, Condillac, Scottish common-sense philosophers, and non-Kantian historians of philosophy like Dieterich Tiedemann.[4] The result is a work that looks strikingly unfamiliar to modern-day readers. Degérando relies on two other conceptual pairs (dogmatism and scepticism, materialism and idealism) besides empiricism and rationalism. He identifies not two but three main groupings of early modern authors: the schools of Bacon, Descartes, and Leibniz. He grafts the notions of empiricism and rationalism onto an account that praises eclecticism and promotes a version of experimental philosophy whose main sources were Bacon and Condillac. He surveys the history of philosophy twice, first chronologically and then systematically, developing a taxonomy of philosophical systems.

Like Tennemann, Buhle was a Kantian, and the RED plays a significant role in his account of philosophy. However, Buhle's account is more factually oriented than Tennemann's and less explicitly informed by his Kantian outlook. For this reason, and also because Tennemann's *Manual* had a stronger long-term influence than Buhle's and Degérando's works, we focus on Tennemann in this chapter.[5] We do not discuss the degree to which later philosophers and historians, such as Kuno Fischer, William James or the British Idealists, influenced the standard historiography of early modern thought.[6] This chapter shows that, several decades before Fischer, Green, or James, Tennemann's works developed in considerable detail the traditional historiographical paradigm of seventeenth- and eighteenth-century philosophy.

use the standard narrative, we argue that its main features were developed decades earlier, as can be seen from Tennemann's works. Green did not employ the standard narrative (see Vanzo 2016a, pp. 269–72).

[3] Additionally, Friedrich August Carus, a psychologist influenced by Kant and Jacobi, employed the notions of empiricism and rationalism in a history of philosophy that was published posthumously in 1809 (Carus 1809, see, for example, pp. 131, 277, 278, 514, 638, 677). This work is incomplete and does not include a section on early modern philosophy. On Carus, see Braun 1990, pp. 269–73.

[4] See Piaia 2004, pp. 31–87; Manzo 2016.

[5] On the influence of Tennemann's, Buhle's, and Degérando's works, see, respectively, Micheli 1992, pp. 137–53; Santinello 1988a, pp. 1011–8; and Piaia 2004, pp. 80–7.

[6] See Vanzo 2016a. On William James and the teaching of the two triumvirates at Harvard in 1895, see Anstey 2019, pp. 41–2.

9.1 Empiricism versus Purism in the 1780s

Kant discussed empiricism and rationalism in four works published during his lifetime: the *Critique of Pure Reason* (1781/7), the *Critique of Practical Reason* (1788), the *Critique of the Power of Judgment* (1790), and the essay against Eberhard (*On a Discovery whereby any New Critique of Pure Reason is to be made Superfluous by an Older One*, 1790). By the time Kant published the two latter works, the RED was commonly used among German philosophers, although it had yet to enter the histories of philosophy. This section explains how the RED made its way into the German philosophical vocabulary during the 1780s.

Kant's first *Critique* was largely ignored in the first two years after its publication. Its first substantive reviews were published in 1783. From that moment, the *Critique* moved slowly toward the centre of attention.[7] Within a few years, the Kantian 'insurrection exploded everywhere; war was declared in all corners of Germany. There were manuals, dictionaries, commentaries, new expositions of "the only true viewpoint", letters, even poems: all to explain Kant's philosophy or to praise it' (Feder 1803, §2, quoted in Feder 1825, p. 353).[8] As the metaphor of the insurrection suggests, not everybody was singing the praises of Kantian philosophy. The protracted dispute between Kantians and anti-Kantians loomed large in the literary journals. By 1789 there was

> a large number of notes, evaluations, essays, letters, etc. on the learned dispute between Kant's friends and foes in the publications which are so frequent in these days and carry the name of *Journal*, *Museum*, *Bibliothek*, *Merkur*, *Litteraturzeitung*, *Gelehrte Anzeigen*, etc. Whoever does not want to remain a total stranger in the realm of sciences must consult at least one or the other of these publications. (Reuß 1789, p. 46)[9]

In this early literature, Kant was often criticised for ascribing new, technical meanings to a large number of terms: 'intuition', 'idea', 'deduction', and so on. In the words of a reviewer, 'if the honourable and witty man did not live so much in the clouds, if he did not use a terminology of his own and if his sentences were shorter and simpler, he might be less exposed' to the 'danger' of being misunderstood.[10] In an environment dominated by would-be popular philosophers, 'philosophers for the world' (Böhr 2003), obscurity and technicalities were serious shortcomings.

[7] It is often claimed that the publication of Reinhold's *Letters on Kantian Philosophy* in 1786–7 was decisive in turning the tide in Kant's favour. While the *Letters* had a significant influence, Kuehn (2006) has shown that Kant's philosophy gathered increasing favour between 1783 and 1786, before the *Letters* were published.

[8] See Anon. 1787, p. ix, quoted in Hinske 1975, p. ix.

[9] On the role of philosophical journals in the early Kant reception, see Sassen 2000a, pp. 42–8.

[10] Anon. 1783, as quoted in Kuehn 2006, p. 642; see Meiners 1786b, Preface, sig. b5 5–7.

Criticisms were also directed to the new meanings that Kant gave to the terms 'rationalism' and 'empiricism'. A critic took them to be useless: 'How rich is the Critical Philosophy of new technical terms: "Topic", "empiricism", "mysticism", "rationalism of practical reason"! And what is gained with this whole terminology? Sentences of the same kind as those that we already know' to be true (Brastberger 1792, p. 132). Another critic complained that 'empiricist' and 'rationalist', like 'Critical' and 'un-Critical', were used as terms of abuse, diverting philosophers from a dispassionate search for truth.[11]

Despite these criticisms, the terms 'empiricism' and 'rationalism' appeared in a growing number of expositions, textbooks, commentaries, and lexica of Kant's philosophy,[12] as well as outlines of new philosophical positions compared to Kant's.[13] All these were written by Kantians or by authors influenced by Kant and employed 'empiricism' and 'rationalism' in Kant's sense. The anti-Kantians too contributed to spreading the use of 'empiricism' and 'rationalism'. They did so by engaging in a dispute with Kantians, to which we now turn.

As is well known, the first substantial review of the *Critique of Pure Reason* was written by Christian Garve and edited by Johann Georg Heinrich Feder, both of whom favoured experimental philosophy. Other supporters of experimental philosophy attacked Kant shortly after them. Among them was Christian Gottlieb Selle, a respected physician, member of the Berlin Academy, and admirer of Locke's *Essay*. In 1784, he published an 'Attempt at a Proof That There Are No Pure Concepts of Reason That Are Independent of Experience' (Selle 1784). Although this article makes no mention of Kant, its target was his claim that we have non-empirical concepts, namely the categories. Four years later, prompted by the growing success of Kant's philosophy, Selle published a new edition of his *Principles of Pure Philosophy*, which develops a Lockean alternative to Kant's first *Critique*.

A Kant exegete, Carl Christian Erhard Schmid, replied to Selle by publishing 'Some Remarks About Empiricism and Purism in Philosophy'. Schmid's 'Remarks' is 'a critical parallel of two philosophical ways of thinking that are diametrically opposed to one another': Selle's 'universal empiricism' and Kant's 'rationalism or *purism* [*Purismus*]'.[14] Schmid contrasts Kant's and Selle's views concerning the nature and working of sensibility, understanding, and reason; whether we have non-empirical intuitions and concepts; whether human reason can operate independently from sensory inputs; our knowledge of the laws of nature; the kind of certainty or necessity that they enjoy; whether

[11] Feder 1789, p. 229. Feder used the term 'purist' instead of 'rationalist' in that passage.

[12] See, for example, Schultz 1784, p. 186; Heinicke 1788, p. 58; Jakob 1788, p. 293; Schmid 1788b, pp. 156–7, 162–3, 290; Schmid 1788c, pp. 190, 232; Schultz 1789, p. 217; Schmid 1790, pp. 12–16, 17; Born 1791, pp. 401, 436, 520, 534, 535, 606, 608.

[13] See, for example, Maimon 2004 [1790], pp. 433–8; Holst 1791, p. 154.

[14] Schmid 1788a, pp. 2–3, 8, trans. in Sassen 2000b, pp. 233, 236.

they depend on the constitution of the world or on our cognitive faculties; the foundations of the moral law and of natural theology. Unsurprisingly, Schmid's point-by-point comparison aimed as much to distinguish Selle's empiricism from Kant's philosophy as to show the latter's superiority.

Schmid's essay was followed by similar point-by-point comparisons by Selle and his ally Pistorius.[15] They discussed a similar range of topics to those raised by Schmid, attempting to show the superiority of empiricism over Kantian purism. Being widely read, the texts pertaining to this debate contributed to popularising the terms 'empiricism' and 'rationalism' or 'purism'. 'Purism' was introduced by Schmid in 1788 as a synonym of 'noologism', the term used by Kant in the History of Pure Reason. Kant himself used 'rationalism' instead of 'noologism' from 1788 onwards, whereas others followed Schmid in using 'purism'.[16] 'Rationalism' prevailed in linguistic usage in the 1790s as the standard designation for the adversary of empiricism.

In the texts of Schmid, Pistorius, and Selle, 'empiricism' and 'rationalism' were not historiographical categories, imposed on earlier thinkers who did not employ them. They were actors' categories, that is, categories used to single out certain positions within the then current debates. Within those debates, 'empiricism' no longer carried negative connotations, unlike the old notion of empiricism as quackery or inexperience that was only applied to others, never to oneself.[17] To our knowledge, Pistorius (1789) and Selle (1786–7) are the first authors to use the epistemological, Kantian notion of empiricism to designate their own views.[18] Kant's early followers and opponents also used two pre-Kantian expressions, 'empirical philosophy' and 'empiric' [*Empiriker*], claiming for instance that Kant unjustly humiliated empirical philosophy.[19] However, they gave new, post-Kantian meanings to those expressions. Whereas pre-Kantian authors identified empirical philosophers with natural philosophers such as Gilbert[20] or proto-philosophers such as the Jewish patriarchs,[21] Kant's early opponents identified empirical philosophers with empiricists: Locke, Hume, and all those who reject innate concepts and substantive a priori knowledge.

[15] See Selle 1786–7 (published in 1792); Pistorius 1789; and Eberhard 1792, which is based on Selle 1786–1787.

[16] For example, Pistorius 1789; Feder 1789, p. 230; Flatt 1789, p. 104 n.; Breyer 1791, quoted in Hausius 1793, p. 76 n.

[17] For example, Johnson 1768, entry on 'empiricism'. On pre-Kantian notions of empiric and on the shift to the Kantian notion of empiricism, see Vanzo 2014. A similar shift from pre-Kantian to Kantian notions of the empiric took place in the German literature on agronomy between 1800 and 1820: see Lehmbrock 2016.

[18] This point answers Klein's (2007, p. 68) desideratum.

[19] See, for example, the passage by Feder quoted at pp. 231–2, and Reinhold 2008 [1792], pp. 177–8.

[20] See Bacon 2004, 1.62, 64, 98–9.

[21] See Heumann 1716, p. 760; Brucker 1766–7, 1, p. 63.

Feder, Selle, and Pistorius were clear supporters of empiricism in Kant's sense of the term. They explicitly denied the existence of non-empirical concepts and synthetic a priori judgements. For instance, Selle's first polemical article (1784) was, according to its title, an attempt to prove that all concepts are empirical. A substantial portion of the article was an argument for the claim that synthetic judgements can only be known to be true a posteriori (pp. 571–5). Against them, Kantian purists or rationalists contended that there are non-empirical concepts and synthetic a priori judgements.

Schmid, Selle, and Pistorius, among others,[22] had good reason to focus on these issues. Kant had written in 1783 that the 'fate of metaphysics wholly rests' on 'the possibility of synthetic cognition *a priori*' and that the first *Critique* and *Prolegomena* were 'entirely directed' to them (*Prol.*, 4: 377). Nevertheless, Schmid, Selle, and Pistorius did not have the epistemological bias that consists in regarding empiricism and rationalism as solely or primarily epistemological positions. This can be seen from the list of topics discussed by Schmid and his opponents (pp. 261–2 above). They thought of empiricism and rationalism as wide-ranging philosophical options, involving specific conceptions of the working of the mind, the laws of nature, and the foundations of morality and theology.

Schmid and his opponents did not have the classificatory and Kantian biases either. They did not have the classificatory bias because they mainly used the terms 'empiricism', 'rationalism', and 'purism' to designate their own contemporaries. They did not employ them as pigeonholes to categorise most of their early modern predecessors. They did not have the Kantian bias because, in their view, Kant's philosophy was not over and above empiricism and rationalism. They concurred with Kant (see Section 8.4) in seeing his philosophy as an instance of rationalism or, in Schmid's terms, of purism. Kant's early readers were aware that he was trying to develop a third position besides those of Locke, who 'totally *sensitivised* the concepts of the understanding', and Leibniz, who '*intellectualised* the appearances' (A271/B327). Johann Georg Hamann, for instance, acknowledged this in an unpublished review written as early as 1781 (Hamann 1824 [1781], pp. 47–8). However, Kant's early readers did not see him as attempting to go beyond the very dichotomy of empiricism and rationalism.

One might expect that Kant and his disciples differentiated their position from rationalism in the debate with the Wolffians and Leibnizians, which started in 1788. Yet, the texts fall short of this expectation. They contrast Kantian philosophy with Leibnizian philosophy[23] or dogmatic philosophy,[24] Critical idealism with dogmatism,[25] and Kant's critique of pure reason with

[22] For example, Tiedemann 1785; Tittel 1787.
[23] For example, Eberhard 1788–9, p. 289.
[24] For example, Eberhard 1788–9, p. 290.
[25] For example, Eberhard 1789–90, p. 297.

Leibniz's.[26] However, they do not use the terms 'empiricism' and 'rationalism', nor do they contrast Leibniz's rationalism with Kant's non-rationalist philosophy. The first to place Kantian philosophy over and above empiricism and rationalism was Karl Leonhard Reinhold.

9.2 Reinhold on Empiricism, Rationalism, and the Philosophy without Epithets

Reinhold converted to Kantianism in 1786. His *Letters on the Kantian Philosophy*, first published in the journal *Der Teutsche Merkur* in 1786–7, contributed to popularising Kant's views and made Reinhold a well-known, influential intellectual. Whereas the *Letters* presents Kant's moral philosophy as providing a way out of a profound cultural crisis,[27] Reinhold's works from the early 1790s present Kant's theoretical philosophy as providing a way out of the blind alleys of empiricism and rationalism.[28] By then, Reinhold had developed his own system, Elementary Philosophy. Although he was eager to stress that 'Elementary Philosophy' is '*essentially* different from the *Critique of Pure Reason*',[29] Reinhold saw Elementary Philosophy as building upon 'Kantian criticism' and completing the revolution with which Kant overcame the limits of all previous early modern philosophies: 'The insufficiency of *empiricism* brought about *rationalism*, and the insufficiency of the latter sustained the other in turn. *Humean scepticism* unveiled the insufficiency of both of these dogmatic systems, and thus occasioned *Kantian criticism*. The latter overturned *one-sided* dogmatism and dogmatic scepticism' (Reinhold 2011 [1791], p. 132).

The starting points of these historical developments are Locke's empiricism and Leibniz's rationalism, 'the only two *dogmatic* systems that had hitherto been possible': 'The two philosophers laid down, one in the simple representations drawn from experience and the other in innate representations . . . the only foundation of philosophical knowledge possible for the empiricists and the rationalists' (Reinhold 2011 [1791], p. 44). In their search for a foundation of philosophical or scientific knowledge [*Wissen* or *Wissenschaft*], which for Reinhold are synonyms, Locke and Leibniz assumed that 'the *scientific nature* of knowledge [*der Charakter der Wissenschaft als Wissenschaft*] depends on the *immutability* of the representations by means of which the objects of knowledge are thought' (p. 14). Locke held that immutable representations must be simple (p. 14) and that simple representations can only derive from

[26] For example, Eberhard 1788–9, pp. 284–8.

[27] Reinhold 2007 [1790], pp. 12–13, 103–8. Reinhold 1789, too, focuses on moral philosophy.

[28] See Reinhold 2003 [1790], pp. 48, 52–5, 67–8; 2011 [1791]; 1792; 2008 [1792], pp. 22–3, 177–9, 383; 2004 [1794].

[29] Reinhold 2011 [1791], p. 132.

experience (p. 18). His view that empirical representations are the foundation of knowledge is the hallmark of empiricism and a central target of Leibniz's *New Essays*. Leibniz proved 'that the representations that Locke passes off as simple are far from simple; that many of those that Locke derives from outer experience occur only in inner experience; and that the representations of powers and actions of the soul, and in general all representations of the understanding, cannot derive from the senses through perception' (Reinhold 2011 [1791], pp. 19–20). Leibniz held that, rather than deriving from the senses, the foundations of philosophical knowledge are innate concepts and a priori judgements. This claim is the hallmark of his rationalism.

The publication of Leibniz's *New Essays* in 1765 did not prevent Locke's *Essay* from finding widespread acceptance even in Germany. 'And while [Leibniz's and Locke's] followers were busy disagreeing about the external details and the refinements of their systems, David Hume came along' (pp. 44–5) and revealed their mistake. This was believing that we can know mind-independent objects, either on the basis of simple mental representations drawn from experience or by means of innate concepts and a priori judgements:[30] 'Hume confronted this crucial issue about the *conformity* of impressions to their objects; this was what everybody had taken for granted without proof before his time, and he demonstrated that no proof can be offered that is without contradiction' (Reinhold 2011 [1791], p. 45).

Like Locke and Leibniz, Hume assumed that the objects to which our impressions must conform to be true are mind-independent or, in Kant's terms, things in themselves. Kant rejected that '*groundless assumption*' by proving 'that objective truth is entirely possible without knowledge of things in themselves' (2004 [1794], p. 203). On Reinhold's reading, Kant took objective truth to be the correspondence of our mental representations with mind-dependent, phenomenal objects that, unlike things in themselves, we can know (2011 [1791], pp. 66–7). Whereas pre-Kantian philosophers failed to distinguish phenomenal objects from things in themselves (2004 [1794], p. 117), Kant relied on that distinction as the basis for answering the crucial question on the extension and limits of our knowledge. Building on Kant's answer, his disciples – including, of course, Reinhold himself – solved the main disputes in the fields of ethics, natural law, and even theology (1789, pp. 141–54).

This potted history of early modern philosophy was attractive to Reinhold's contemporaries for historiographical as well as philosophical reasons. From a *historiographical* point of view, it places four works that they held in great

[30] For an alternative diagnosis of the mistake of pre-Kantian philosophers, see Reinhold 1789, pp. 45–8, 62. Reinhold writes that Hume 'came along' while Lockeans and Leibnizians were disputing, even if Hume's main works were published before the *New Essays*. Reinhold might have had in mind an increase in Hume's popularity in Germany after 1765, or he might have been referring to disputes between Lockeans and Leibnizians that took place after the publication of the *New Essays*.

esteem (Locke's *Essay*, Leibniz's *New Essays*, Hume's *Treatise*, and Kant's first *Critique*) within a single, coherent narrative. Reinhold describes them as the '*four* main, indispensable books' that illustrate 'the four only possible and necessary *main attempts* of reason that *seeks* philosophy on the *analytic* path' (2004 [1794], pp. 205–6). Leibniz's rationalism, Locke's empiricism, Hume's scepticism, and Kant's Criticism are the four only possible attempts to determine 'the foundation of philosophical knowledge'.[31]

From a *philosophical* point of view, Reinhold's narrative places the Kantian and post-Kantian philosophies that had become increasingly popular in the early 1790s at the summit of the development of human reason. Kant's philosophy '*unifies* the acclaimed but contradictory viewpoints from which *Locke* and *Leibniz* investigated the human spirit' (2007 [1790], p. 107). It is the end point of a dialectical process that stretches through seventeenth- and eighteenth-century philosophy (Breazeale 1998, p. 130). This process recalls Kant's attempts to solve the antinomies by mediating between theses and antitheses,[32] but it also anticipates the dynamics of Hegel's dialectic. Like Hegel's theses and antitheses, empiricism and rationalism are opposite positions that bring to light each other's limits: 'the insufficiency of *empiricism* brought about *rationalism*, and the insufficiency of the latter sustained the other in turn' (Reinhold 2011 [1791], p. 132). Humean scepticism brings about an *Aufhebung* of empiricism and rationalism, in all three meanings of Hegel's notion of *Aufhebung*: it *goes beyond* those positions, while *removing* their mistakes and *retaining* their correct insights. Scepticism removes the mistaken assumption, shared by empiricists and rationalists, that we can know things in themselves, either on the basis of experience or through innate concepts and a priori judgements. Scepticism retains the assumption of empiricists and rationalists that objective truth is the correspondence of representations with things in themselves, but it shows that, given that assumption, we cannot know which representations are true. In doing so, scepticism goes beyond empiricism and rationalism because it reveals their failure to provide foundations for knowledge and 'and hence the absolute necessity of a reformation or even revolution in philosophy' (Breazeale 1998, p. 123).

Reinhold sometimes calls empiricism and rationalism positive dogmatism, scepticism negative dogmatism[33] – a rather ironic choice, given that sceptics saw themselves as the only non-dogmatic philosophers. Reinhold's classification

[31] This is the title of Reinhold 2011 [1791]. Besides these 'four only possible' attempts, Reinhold occasionally mentions the eclecticism of popular philosophers (e.g., 2007 [1790], p. 128; 2011 [1791], p. 131). He does not include it in his classification of philosophical positions. He does not include his own elementary philosophy either. This might be because Reinhold does not present his system as a philosophical movement besides others, but as philosophy par excellence ('without epithets').

[32] Heinz (2004, p. 340, n. 9) mentions Herder and Kant's philosophy of history as possible sources for Reinhold's conception of the historical development of philosophy.

[33] Reinhold 2004 [1794], pp. 115–16.

is represented in Figure 9.1. As scepticism goes beyond the two forms of positive dogmatism, so Kant's philosophy goes beyond positive and negative dogmatism.[34] Kant retains the dogmatists' and sceptics' claim that science relies on immutable truths (2011 [1791], p. 56), while rejecting their conception of objective truth.[35]

Since, for Reinhold, Kant synthesises empiricist, rationalist, and sceptical claims, he is not a rationalist as Schmid and Kant himself had claimed. Kant's philosophy goes over and above empiricism and rationalism:

> Of course, many of the most acute thinkers had already suspected that, in the dispute about the origin of representations and, by implication, about the source of human knowledge, the truth must lie midway between the opposing claims championed by those two great men. By putting together whatever truth there is in Locke's empiricism and in Leibniz's rationalism it had to be possible to erect a system that would rise above all the objections offered by Hume's scepticism, and satisfy its rigorous but fair requirements. But what even the sharpest thinkers could only *guess at*, but could not see clearly, this Kant actually provided in the *Critique of Pure Reason*.
>
> (Reinhold 2011 [1791], p. 56)

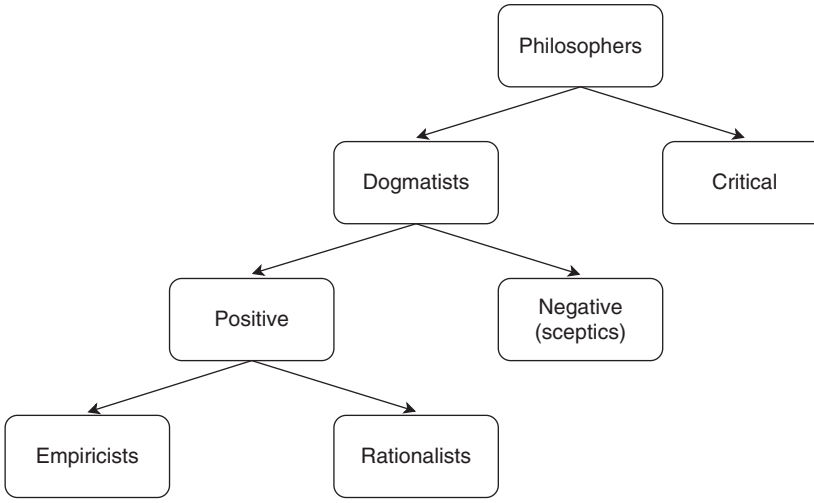


Figure 9.1 One of Reinhold's classifications of the main philosophical movements. An alternative classification identifies dogmatists with positive dogmatists

[34] Reinhold 2004 [1794], pp. 14–15, 115, 201–6; 2011 [1791], pp. 55–6, 132.

[35] Reinhold goes at some length to describe the empiricist, rationalist, and sceptical claims that he and Kant accept and those that they reject (2003 [1790], pp. 67–8).

Kant's Critical philosophy must in turn give way to Reinhold's Elementary Philosophy (p. 104). This philosophy 'can no more be called *Critical* as it can be called empiricist, rationalist or sceptical; it is a philosophy *without epithets*',[36] philosophy par excellence (1791, p. 32). It is the end point of the steady march of the human mind towards science.[37] While elementary philosophy encompasses ethics, natural law, and natural theology,[38] the engine of progress which leads to its discovery, at least according to Reinhold's works from the early 1790s, does not lie in those disciplines. It lies in the disputes between empiricists, rationalists, and sceptics on the foundations for human knowledge.[39]

Reinhold's history of philosophy is selective and not entirely consistent. For instance, Reinhold states in 1791 that Lockeans were unable to refute Leibniz (2011 [1791], p. 20), but in 1792 he claims that Leibnizians and Lockeans refuted each other (2008 [1792], pp. 22–3). Reinhold offers no detailed analysis of those disputes in order to adjudicate between the contenders. Fleshing out his historical sketches into a detailed, consistent, and textually based history of modern philosophy is a task that Buhle and Tennemann would accomplish. What Reinhold did accomplish is providing an outline of the history of modern philosophy from a broadly Kantian point of view. Like Kant, Reinhold regarded the historiography of philosophy as an eminently philosophical discipline, to be carried out from the privileged point of view of the only true philosophy.[40] Unlike Kant, Reinhold placed the epistemological conflict between empiricism and rationalism and Kant's *Aufhebung* of them both at the centre of his narrative, introducing the Kantian and epistemological biases within the historiography of early modern philosophy.

9.3 Tennemann's Theory of the History of Philosophy

A translator and historian of philosophy, Wilhelm Gottlieb Tennemann embraced Kant's Critical philosophy in 1791 after reading Reinhold's *Letters on the Kantian Philosophy*. He soon adopted Reinhold's perspective in his own

[36] Reinhold 2011 [1791], p. 132, trans. and italics modified.

[37] Any further development will be progress within science, rather than towards it (2008 [1792], pp. 177–8). Reinhold intimates that progress toward science is a necessary process: note the term 'necessary' in the passage from his 2004 [1794], pp. 205–6, quoted above, p. 266. See Breazeale 2010, pp. 104–7. On how Reinhold's philosophy derives from his reflections on the history of philosophy, see Ameriks 2004.

[38] Reinhold had a keen interest in those disciplines, as can be seen from his 1789 and 2007 [1790].

[39] There are other classifications of previous philosophers in Reinhold's works from the early 1790s, most notably the metaphysical classification of his 2004 [1794], pp. 113–51. The epistemological classification is the basis for Reinhold's account of the four '*main attempts*' (p. 206) in the history of modern philosophy.

[40] See Reinhold 1791, pp. 32–4; Jacobi 1869, p. 137. Kant's and Reinhold's statements on the history of philosophy gave rise to lively debates on the methodology of philosophical historiography. See Di Bella 2008, Longo 2008, and Micheli et al. 2015, pp. 769–87.

historiographical work. For instance, in the introduction to the translation of Hume's *Treatise* that he published in 1794, he explained that 'Hume's writings are of philosophical interest for two reasons. First, because they contain one of the four possible philosophical systems' – a reference to Reinhold's 'four main attempts'.[41] 'Second, because they are the proximate cause of the admirable philosophical revolution' that led Kant and Reinhold to transform philosophy into a science.[42] Shortly after 1794, Reinhold abandoned Elementary Philosophy for Fichte's idealism. With the tide turning in favour of Fichte's, Schelling's, and Hegel's systems, both Kantianism and Elementary Philosophy went out of fashion. Nevertheless, Tennemann maintained his Kantian and broadly Reinholdian commitments until his death in 1819. They underpin his eleven-volume *History of Philosophy* and his shorter *Manual of the History of Philosophy*.

According to Tennemann, 'the Critical inquiries of the philosopher of Königsberg had the most beneficial consequences not only for philosophy itself, but also for the history of philosophy' (Tennemann 1801, col. 27).[43] These consequences concern the object of the history of philosophy, its unity, and the selection and organisation of materials.[44]

The object of the history of philosophy. What should history of philosophy be, over and above the history of ideas? According to Tennemann, '*History of Philosophy*, as its name suggests, can be neither history of philosophers, nor history of ideas [*Philosopheme*]. It includes both, but it subordinates them to a higher purpose and point of view. This is the exposition of the emergence and development of philosophy as a science' (Tennemann 1798–1819, 1, Preface, sig. * 3 2).[45] This might not seem to be of much help because, as Tennemann and his predecessors knew well,[46] the notion of philosophy has changed over time. Historians of philosophy might either trace the history of reflections on those topics that are now considered philosophical, or they might adopt the notions of philosophy that were current in each period of study.[47] Either option has significant potential drawbacks. If historians focus on the issues that are now considered philosophical, they are likely to overlook issues in which past thinkers had great interest and which deeply influenced what is still regarded as their genuinely philosophical contributions. On the other hand, if historians adopt older notions of philosophy, they will dwell on many topics

[41] See Reinhold 2004 [1794], pp. 205–6, quoted above, p. 266.
[42] Tennemann 1794, p. v. This volume includes an essay on scepticism by Reinhold.
[43] See also Tennemann 1795, p. 332; 1798–1819, 1, p. lxxvii.
[44] On Tennemann's theory of the history of philosophy, see Santinello 1965 and Micheli 1992, pp. 9–47.
[45] See Tennemann 1798–1819, 1, pp. xlvi–xlvii. The term 'Philosopheme' designates philosophical claims or doctrines.
[46] See, for example, Brucker 1766–7, 1, pp. 3–7.
[47] Meiners 1781–2, 1, p. xxiii, advocated the second option.

that are no longer philosophically relevant, and much of their work will be of little interest to current-day philosophers.

Tennemann's way out of this dilemma is informed by his persuasion that Kant has laid out the foundations of the one true philosophy, or, as Tennemann prefers to say, of philosophy as a science. Whereas historians of ideas can trace the history of true and false theories, historians of philosophy should focus on the one true philosophy and use it as a guide to determine what topics to focus on. Historians of philosophy should study the development of those issues and topics that are part of Kant's philosophy. Any other choice would mean relying on a defective notion of philosophy.

A natural objection to this stance is that it leads historians to force a specific notion of philosophy on authors that were foreign to it. Since Aristotle's, Bruno's, and Descartes' philosophical projects have a very different scope from Kant's, it is unclear why looking at them with Kantian spectacles should help one to understand them. Yet, according to Tennemann, the philosophical enterprises of Aristotle, Bruno, and Descartes are more closely related to Kant than one might suppose. Insofar as they all aimed to develop comprehensive philosophical systems that provide definitive answers to the major philosophical questions, they were trying to articulate the philosophy that Kant eventually spelled out. 'Every philosophising is a striving of reason to realise this idea [Kant's ideal] of science' (1798–1819, 1, p. xxviii).

Philosophers did not easily achieve that aim. Only after many centuries of failed attempts did reason become Kantian. 'Since philosophy as a science did not develop at once, but developed gradually and is the product of many thinkers . . . it is possible to conceive of a history that describes this progressing culture of reason and the gradual forming of philosophy' (Tennemann 1798–1819, 1, p. xxix).[48] This history is the history of philosophy, that is, a 'pragmatic [i.e., a posteriori] description of the gradual, progressive formation of philosophy as a science' (Tennemann 1816, p. 7).[49]

For Tennemann, then, philosophical reflection is a teleological process. It is the history of reason's strivings toward Kantian doctrines. His unapologetically Whiggish approach is likely to sound implausible to modern ears, but it was a natural view for a committed Kantian to endorse in the early nineteenth century. It is the combination of a venerable Aristotelian assumption – all humans have a natural desire to know[50] – with the view that Kant first outlined the knowledge that all humans desire to achieve.

[48] Among Tennemann's contemporaries, Tiedemann held that the history of philosophy should 'describe the uninterrupted progress of reason' (1791–7, p. ix) and the 'growth of science' (p. viii). Early eighteenth-century historians such as Brucker and Deslandes employed a weaker notion of philosophical progress. See Longo 2015, p. 646.

[49] See Tennemann 1795, p. 325; 1798–1819, 1, p. xxix.

[50] *Metaphysics* A 980 b 24; Tennemann 1816, p. 2.

The unity of the history of philosophy. Even if we restrict our attention to philosophy in the Kantian sense, we will find that, in the course of time, thinkers focused on different problems, raised widely differing questions, and answered them in the most diverse ways. As a consequence, the contents of a general history of philosophy might seem rather disparate, unless historians single out some overarching themes that give continuity to their narrative. Tennemann's Kantianism provides him with such an overarching theme. Kant's ideal of philosophy gives 'unity' to 'the manifold of history'.[51] This is because unity

> can only be brought into the manifold of the history of philosophy through the *unity of the aim* of the activity of reason. Through that unity all systems and theories, all attempts and efforts, even if they are very different from one another in content and form, whether successful or unsuccessful, indeed even errors, are related to a [single] point, which is the rational idea of philosophy. Therefore, everything in the history of philosophy must be related to it; only through it is it possible to follow the often mazy and puzzling course of reason and to display the progress or regress on the way toward science.
>
> (Tennemann 1798–1819, 1, pp. xliv–xlv)

If the historian does not relate past doctrines to the one true philosophy, 'the mind loses its way among the details of each particular, a particular recalls another and the whole vanishes in front of one's eyes like the images of the magic lantern'.[52] By relating Kant's true philosophy to all other philosophies, it is possible to judge their value.[53] The more a doctrine resembles, anticipates, or prepares Kant's views, the more positively Tennemann views it. Ultimately, for Tennemann, the mistake of all pre-Kantian philosophers is that they were not Kantians.

These statements, that most clearly express Tennemann's endorsement of Critical philosophy, are the least influential aspect of his historiography. They were outdated even to many of his contemporaries (Micheli 1992, pp. 138, 143). Kant's philosophy unifies and permeates Tennemann's historiography in other more subtle and influential ways. They concern the selection and organisation of materials.

The selection and organisation of materials. Even an eleven-volume history of philosophy like Tennemann's must be selective. Less significant doctrines must be omitted or summarised to make room for in-depth discussions of the most important topics. Kant's philosophy provides Tennemann with a criterion to decide which topics to focus on. The selection of materials must be the most conducive to displaying the progression of philosophy

[51] Tennemann 1798–1819, 1, p. xliv; see 1795, pp. 330–1.
[52] Tennemann 1798–1819, 1, pp. xxiv–xxv, see pp. lxvi–lxvii.
[53] Tennemann 1798–1819, 1, pp. xxviii–xxix, see p. lxvii.

toward its Kantian end point (Tennemann 1798–1819, 1, pp. lxiii–lxiv). Few historians would accept Tennemann's suggestion. Nevertheless, as we shall see, the materials that Tennemann selects by applying that criterion resemble in many respects the standard accounts of early modern philosophy that today's readers are familiar with.[54]

A history of early modern philosophy can be organised on the basis of various criteria: chronological and geographical factors, actors' categories like eclecticism and experimental philosophy, or historiographical notions like empiricism and rationalism. According to Tennemann, historians of philosophy should illustrate the progress of human reason toward Kantian philosophy. To this end, they should group philosophers in the way that best displays the '*formation and development of philosophy as a science*' (Tennemann 1798–1819, 1, Preface, sig. * 4 1).[55] 'Hence, the *periods* and the *historical partitions* must *be* [determined by] *important changes in the scientific course of philosophy*' (p. lxix). The most significant changes on which Tennemann focuses concern philosophers' views on the foundations of knowledge, specifically on whether there are non-empirical concepts and whether we can have substantive a priori knowledge. The affirmative and negative answers to these questions define the categories of rationalism and empiricism. Tennemann's history of seventeenth- and eighteenth-century philosophy is, for the most part, a history of the development of these movements and their convergence in Kant's final synthesis.[56]

9.4 Tennemann's History of Early Modern Philosophy

Tennemann divides early modern philosophy into two periods. The first goes from the fifteenth to the seventeenth century. It is characterised by the 'reproduction and combination of ancient systems' (1816, p. 234): Aristotelianism by Zabarella and others, Platonism by Ficino and Pico della Mirandola, scepticism by Montaigne, and so on. The second period goes 'from Bacon and Descartes to Kant' (p. 271) and is defined by the development of empiricism and rationalism. Some empiricists and rationalists were also revising ancient doctrines. For instance, the empiricist Gassendi renewed Epicureanism, and the rationalist Cudworth was a Platonist.[57] However, the emergence of empiricism and rationalism was far more significant than the

[54] For a dated but highly influential example of such accounts, see Copleston 1958, 1959, 1960.

[55] See pp. lxiii–lxiv.

[56] Tennemann singles out empiricists and rationalists in every historical period. His history is a 'typological history of philosophy' (Micheli et al. 2015, p. 781) as it identifies instances of four types of philosophy (empiricism, rationalism, scepticism, and mysticism) in every age.

[57] Tennemann 1798–1819, 10, p. 148 and p. 502.

occasional revival of ancient doctrines in the seventeenth and eighteenth century. We focus on those two centuries in the rest of this chapter.

The centrality of epistemology. Philosophers' attention in that period focused primarily on theoretical philosophy, especially on 'the question of the origin, truth, and certainty of knowledge'.[58] In line with these statements, Tennemann's *Manual* devotes four times as many pages to theoretical philosophy as it does to practical philosophy.[59] Tennemann's emphasis on epistemological questions informs his presentation of early modern doctrines.[60] For instance, Leibniz's monadology is primarily an ontological doctrine concerning the nature of substances. However, when Tennemann introduces it, he immediately emphasises its epistemological dimension: 'the *monadology* is the centre-point of Leibniz's system, thanks to which he believed to have found the first foundations of real knowledge' (1816, pp. 308–9).

Despite his focus on epistemology, Tennemann does not claim that all pre-Kantian philosophers were primarily epistemologists. He acknowledges that Spinoza's main interest was in metaphysics (1798–1819, 10, p. 398) and that Bacon's most notable contributions were in the field of natural philosophy (pp. 11, 24, 26). Tennemann would agree with Tom Sorell (2000, p. 55) and Stephen Gaukroger (2010, p. 156) that Descartes was not primarily a philosopher of the 'pure inquiry'.[61] 'He was very interested in *metaphysics*' (1798–1819, 10, p. 264), but physics 'was closer to his heart' (p. 251). It is also the part of his system that he developed in greater detail (pp. 263, 398).

Despite these statements, Tennemann devotes little space to natural philosophy. He is not indifferent to it, but he never places it in the foreground. The *Manual* does not even mention Robert Boyle or the Royal Society, and the *History* makes only passing mentions of Copernicus, Kepler, Galileo, and Torricelli.[62] Even Newton is dealt with rather briefly.[63] The exposition of Descartes' *Principles of Philosophy* is confined to the more metaphysical Books 1 and 2, omitting the cosmological and cosmogonical theories developed in Books 3 and 4.

These choices are in line with Tennemann's aims. Kant's philosophy distinguishes sharply a priori questions belonging to metaphysics and (what we now call) epistemology from the empirical inquiries of natural science. It focuses primarily on the former, leaving the latter to (what we now call) working

[58] Tennemann 1816, p. 335 and p. 273.

[59] See Tennemann 1816, pp. 275–335 on theoretical philosophy, pp. 335–52 on practical philosophy, as noted in Micheli 1992, p. 118. It is not possible to carry out a similar comparison for Tennemann's *History*, as he died before writing the volume on moral philosophy in the seventeenth and eighteenth centuries.

[60] For example, Tennemann 1798–1819, 11, pp. 1–2.

[61] See the title of Williams 1978.

[62] Tennemann 1798–1819, 10, p. 182.

[63] Tennemann 1798–1819, 11, pp. 76–82.

scientists. Consistent with his intent to trace the ancestry of philosophy in the Kantian sense, Tennemann makes only passing remarks on the history of natural philosophy. He even sometimes suggests that natural philosophy, strictly speaking, is not even part of philosophy, anticipating William Whewell's distinction between the philosopher and the scientist.[64] For instance, he states that Descartes 'was not only a philosopher, but also a mathematician and a student of nature [*Naturforscher*]'.[65] This is unfortunate because, as is now widely accepted among historians, it is profitable to interpret several doctrines of early modern philosophers in the light of their natural philosophical concerns and methodology.

By focusing on epistemology, Tennemann follows in Reinhold's footsteps. Ethics, rather than epistemology, is the centre of both Kant's and, at least in the 1780s, Reinhold's philosophical interests. However, Kant prepared his practical philosophy with an investigation into the origins and foundations of knowledge, and Reinhold, in the early 1790s, saw that investigation as synthesising the best insights of the most important early modern philosophers: Locke, Leibniz, and Hume. Like Reinhold, Tennemann held that focusing on the epistemological views of Kant's predecessors was the best way to show how Kant's philosophy builds upon their achievements. What many would now condemn as an unwarranted epistemological bias was for Tennemann a deliberate choice.

Empiricism and rationalism. Once philosophers started focusing on epistemological matters, 'different systems emerged, which were distinct from one another in their principles as well as their results, depending on whether they regarded experience or reason as [the main] source of knowledge. The disagreement between the systems and pretensions of dogmatists gave new impulse to scepticism' (Tennemann 1816, p. 273). Among the dogmatists, Bacon was the first major philosopher to focus on experience. Descartes was the first to focus on speculation and a priori reasoning.[66] Due to their influence, 'reason fell in a conflict between the tendencies toward experience and toward an extreme obsession for demonstration . . . between speculation and common sense' (p. 274), empiricism and rationalism. A third form of dogmatism was put forward by the mystics

[64] On Whewell's introduction of the term 'scientist' as opposed to the wider and 'more lofty' term 'philosopher', see S. Ross 1962, p. 72.

[65] Tennemann 1798–1819, 10, p. 215; see p. 283 for an implicit distinction between *Physik* and *Philosophie* and p. 77 for the claim that Hobbes' natural philosophy does not belong in Tennemann's *History*. Like Tennemann, Buhle implies that natural philosophy [*Physik*] is distinct from philosophy. See, for example, Buhle 1796–1804, 6.2, pp. 543, 608, 890, 1006. Wilhelm Traugott Krug, who succeeded Kant as chair of logic and metaphysics at the University of Königsberg, held that natural philosophy is not part of philosophy in the narrow or the broad sense, but only in the broadest sense of the term. See Krug 1827, p. 303.

[66] *Pace* Gaukroger (1993, p. 168), the 'reading of Descartes as founder of a [rationalist] school' is 'first set out in detail' in Tennemann's *History* (1798–1819, 10, pp. 4, 198–303), not in Kuno Fischer's works.

[*Mystiker* or *Schwärmer*], who 'sought the source of philosophical knowledge in revelations' (1798–1819, 10, p. 3). Scepticism on the one hand, empiricism, rationalism and mysticism on the other, are the four philosophical movements singled out by Tennemann, as summarised in Figure 9.2.

A list of the seventeenth- and eighteenth-century philosophers discussed for at least one section each in Tennemann's *History* is provided in Table 9.1. A glance at Jakob Brucker's (1766–7, 6, pp. 1029–30) pre-Kantian classifications, represented in Table 9.2, will suffice to note how radically they differ from Tennemann's post-Kantian classifications.[67] The anti-Kantians Meiners and Tiedemann, both partial to experimental philosophy, discussed early modern philosophers in a chronological order, eschewing large-scale classificatory schemas.[68]

Nearly all philosophers discussed by Tennemann fall within one of his four main categories.[69] However, Tennemann does not attempt to force each of

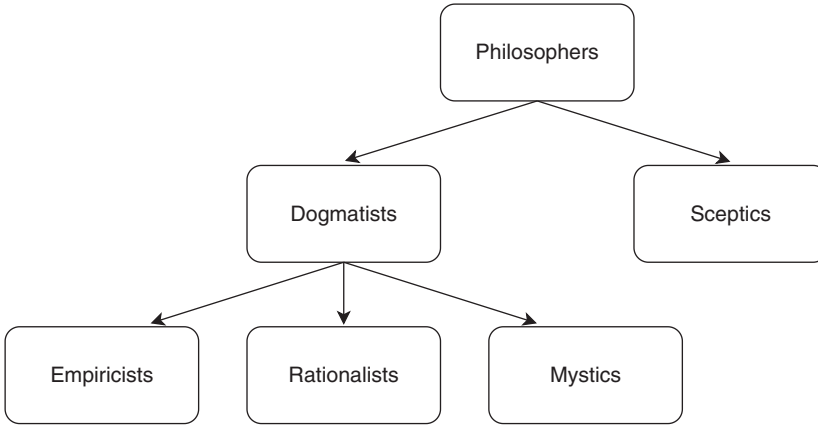


Figure 9.2 Main philosophical movements of the seventeenth and eighteenth centuries according to Tennemann

[67] On Brucker's periodisations, see Longo 2011, pp. 514–19. On his account of early modern philosophy, see Longo 2011, pp. 533–6.

[68] Meiners (1786a) discussed, respectively: Descartes, Malebranche, Spinoza, Bayle, Locke, Shaftesbury, Rochefoucauld, Clarke, Leibniz, Pufendorf, Thomasius, Wolff, and Berkeley. Tiedemann (1791–7, vol. 6) focused on Hobbes, Gassendi, Descartes, Spinoza, Locke, Leibniz, Wolff, and Berkeley. For a summary of further classifications, see Freedman 1985, pp. 131–6.

[69] The categorisation of Herbert of Cherbury is the most perplexing. Tennemann classes him as an empiricist, even if he was partial to innate cognitions and principles (Tennemann 1816, pp. 112, 139). It is unfortunate that Tennemann does not discuss Robert Boyle in detail. Later historians regard him as an empiricist, yet he was partial to innate ideas. See, for example, Boyle, *The Christian Virtuoso, 1*, B 11 300–1, 315, and 326.

Table 9.1 *Seventeenth- and eighteenth-century philosophers discussed for at least one section each in Tennemann's* History of Philosophy, *vols. 10–11*

Author	Pages	Classification
Bacon	45	Empiricist
Hobbes	58	Empiricist
Herbert of Cherbury	18	Empiricist
Gassendi	54	Empiricist
Bérigard	7	Empiricist
Böhme	15	Mystic
Descartes	105	Rationalist
Geulincx	10	Rationalist
Bekker	4	Rationalist
Malebranche	57	Rationalist
Spinoza	119	Rationalist
Parker	5	None
Cudworth	7	Rationalist
More	12	Rationalist
Poiret	4	Mystic
de Villemandy	1	Mystic
Hirnhaim	3	Mystic
Mothe le Vayer	2	Sceptic
Glanvill	2	Sceptic
Locke	69	Empiricist
Newton	6	Empiricist
Leibniz	122	Rationalist
Tschirnhaus	24	None
Thomasius	16	None
Huet	5	Sceptic
Bayle	28	Sceptic
Condillac	13	Empiricist
Bonnet	10	Empiricist
Diderot and d'Alembert	5	None
Author of *System of Nature*	32	Empiricist
La Mettrie	8	Empiricist
Brown	3	Empiricist
Clarke	13	None
King	7	Rationalist
Collier	5	None
Berkeley	13	Empiricist
Hume	51	Sceptic and Empiricist

Table 9.1 *(cont.)*

Author	Pages	Classification
Reid	11	Empiricist
Beattie	5	Empiricist
Oswald	1	Empiricist
Priestley	24	Empiricist
Price	3	Rationalist

Authors are listed in the order in which they appear in the text. Some of the classifications are only implicit in Tennemann's text.

Table 9.2 *Jakob Brucker's classification of seventeenth- and eighteenth-century philosophers*

	Kinds of philosophers	Examples
Reformers of . . .	Aristotelian-Scholastic philosophy	Riccioli, Fabri
	Aristotle's authentic philosophy	Thomasius, Scheibler
	Pythagorean-Platonic-Cabbalistic philosophy	Gale, Cudworth, Burne
	Parmenidean philosophy	Bérigard
	Stoic philosophy	Scioppius, Gataker
	Democritean-Epicurean philosophy	Gassendi, Charleton
Authors of new philosophies	Recent sceptics	Hirnhaim, Huet, Bayle
	Mosaic philosophers	Alsted, Comenius
	Theosophists	Fludd, van Helmont, Poiret
	Syncretist philosophers	Huet, Cudworth, Alsted
	Enemies of philosophy	Bayle, Huet, Poiret
Eclectics who revived . . .	Logic	Bacon, Gassendi, Malebranche, Locke
	Natural philosophy	Boyle, Huygens, Newton
	Metaphysics	Descartes, Leibniz, Wolff, Spinoza
	Moral philosophy, natural law	Montaigne, Grotius, Pufendorf
	Political philosophy	Budde, Thomasius

Brucker developed a rather complex classificatory schema. This table includes only those categories within which he placed seventeenth- or eighteenth-century philosophers. Some philosophers fall under more than one heading.

them within a single category. He classes a few authors neither as empiricists nor as rationalists, mystics, or sceptics,[70] and he places some philosophers within more than one category. For instance, Pierre Bayle was a sceptic at heart, but he also made some dogmatic claims.[71] Tennemann also acknowledges that other categories can be usefully applied besides the four main ones. For instance, he groups together Collier and Berkeley as idealists.

Tennemann portrays relatively few seventeenth- and eighteenth-century philosophers as sceptics or mystics. He classifies most as either empiricists or rationalists, including all of those whom Tennemann regards as the most prominent authors (Figure 9.3). 'Empiricism and rationalism are . . . the two systems in which philosophers were mostly interested' (1798–1819, 10, p. 6). Yet despite the centrality of these movements, Tennemann does not mention them

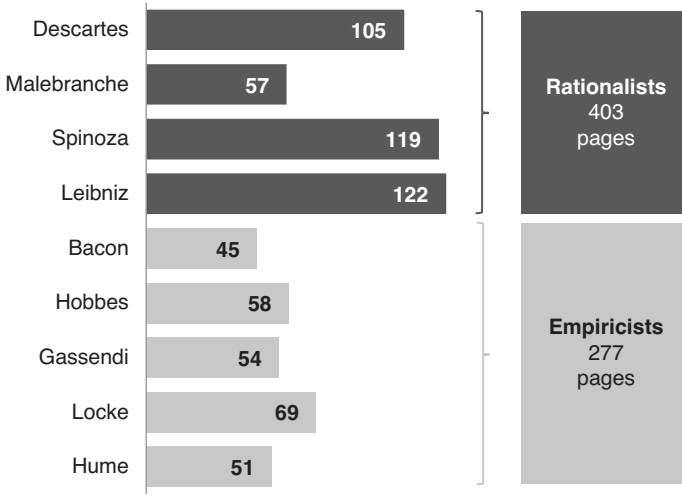


Figure 9.3 Seventeenth- and eighteenth-century philosophers discussed for at least forty-five pages in Tennemann's *History of Philosophy*, vols. 10–11. All other philosophers are discussed for fewer than twenty pages

[70] *Pace* Hochstrasser 2000, p. 216, for whom Tennemann classes all early modern authors as either empiricists or rationalists. Among the authors that are not categorised within either of the four main movements, he might have been willing to classify some (such as Diderot and d'Alembert) as empiricists and others (such as Tschirnhaus) as rationalists. In Table 9.1, we have categorised some philosophers on Tennemann's behalf when his text provided clear evidence for the categorisations. Such evidence is lacking for Diderot, d'Alembert, and Tschirnhaus.

[71] Tennemann 1798–1819, 11, p. 263.

at every turn. He mostly uses the terms 'empiricism' and 'rationalism' when he introduces new authors, when he relates their views to the historical development of human reason, and when he critically assesses them.

Tennemann subsumes the distinction between experimental and speculative philosophy within the RED by contrasting the speculations of rationalists like Descartes with the observations of empiricists. For example, 'Spinoza followed the speculative direction of the Cartesian school with originality and deep insight' (1816, p. 289). By contrast, 'Locke gave a new direction to philosophising in the spirit of Bacon, [a direction] opposed to speculation and favourable to observation, especially of [our] inner nature' (Tennemann 1816, p. 294).[72] Tennemann employs the contrast between observation and speculation as a merely lexical variant of the contrast between empiricism and rationalism. The ESD no longer plays any autonomous, significant role in Tennemann's works.

Creating the canon. Nowadays, the canonical triumvirates of empiricists and rationalists comprise Locke, Berkeley, and Hume on one side, and Descartes, Spinoza, and Leibniz on the other. Extended versions of the canon include Malebranche among the rationalists and Bacon, Hobbes, and Gassendi among the empiricists. Tennemann mentions dozens of other empiricists and rationalists in his *History*. However, all the authors that he discusses in greater detail are included in today's extended canon, as can be seen from Figure 9.3, and all the authors included in the canon are given prominence in the *History*, with the sole exception of Berkeley. Surprisingly, the *History* devotes fewer pages to him than it does to Herbert of Cherbury, Ehrenfried Walter von Tschirnhaus, or Joseph Priestley, and less than a quarter of the pages devoted to Malebranche or Gassendi.

The *Manual* places more importance on Berkeley. There, Berkeley is one of the main authors, that is, the authors that are discussed for at least one section each. These are Descartes, Malebranche, Spinoza, Leibniz, Wolff, and Crusius on the rationalist front; Bacon, Hobbes, Locke, Berkeley, and Hume on the empiricist front. They are the same authors who are privileged in the *History*, with the addition of Berkeley, Wolff, and Crusius. However, Tennemann passed away before writing the sections of the *History* on eighteenth-century German philosophers such as Wolff and Crusius.

In quantitative terms, Tennemann privileges the main rationalists over the empiricists (see Figure 9.3). Not only does he devote more pages to the rationalists as a whole than to the empiricists, but he also discusses Descartes, Spinoza, and Leibniz at greater length than any empiricist.[73]

[72] See Tennemann 1798–1819, 11, pp. 12–13, 282. Experimental philosophy was often called observational philosophy in Germany (see Sections 7.6 and 7.7). Accordingly, Tennemann contrasts speculation with observation rather than experiment.

[73] Tennemann was not the first to group together Descartes, Spinoza, and Leibniz. Colin Maclaurin (1750, pp. 90, 99) did so half a century earlier. Unlike Maclaurin, Tennemann

Nevertheless, Tennemann's coverage of the main empiricists is fairly detailed, and he repeatedly stresses Locke's and Hume's historical importance. Although Tennemann discusses Descartes, Spinoza, and Leibniz in more detail than Malebranche, he does not privilege Locke, Berkeley, and Hume over Bacon, Gassendi, or Hobbes. He does not spell out the standard triumvirate of the main empiricists. His works only reflect the extended canon of early modern philosophers.

Dialectical developments. Tennemann's account of early modern philosophy resembles later histories not only for the authors that he privileges, but also for the ways in which he relates them to one another. Tennemann regards Malebranche's, Spinoza's, and Leibniz's philosophies as original developments of Descartes' rationalism.[74] The rationalist train of thought continues with other authors such as Wolff. In contrast with recent interpretations of Wolff that highlight his significant disagreements with Leibniz,[75] Tennemann adopts the long-standing reading of Wolff as a disciple and systematiser of Leibniz's philosophy.[76]

There is as much continuity within the empiricist school.[77] Bacon's 'friend, Thomas Hobbes', 'followed' his insights 'with the greatest rigour and consequence' (1816, pp. 275–6). Tennemann's focus on epistemology enables him to place Hobbes in a trajectory that goes from Bacon to Locke, even though Hobbes' natural philosophy was opposed to Bacon's and Locke's experimentalism. English philosophers saw Locke's *Essay* as 'a prosecution of the great reform that Bacon had started' (1798–1819, 11, p. 66). Berkeley's idealism derives 'from the principle of Locke's philosophy' (p. 427). Hume 'recognized that this idealism cannot be refuted, but it cannot persuade either, hence it leads to scepticism' (p. 427). Thus, Hume 'remained within the boundaries of scepticism' (p. 427). Tennemann severs Hume's scepticism from the earlier, religiously motivated early modern scepticism, presenting it as a development of Locke's empiricist assumptions. Hume is both a sceptic and an empiricist.[78]

Later empiricists and rationalists did not only build upon the premises laid out by previous members of their school, but they also reacted against the members of the other school. For instance, Locke's empiricism is

grouped them together as rationalists, that is, in virtue of their views on non-empirical concepts and a priori knowledge.

[74] Tennemann 1798–1819, 10, pp. 303, 374; 1816, pp. 289, 307.

[75] For example, Corr 1975.

[76] Tennemann 1816, p. 317. This reading has its origins in the 1720s, when a disciple of Wolff, Georg Bernhard Bilfinger (1725), emphasised the continuity between Leibniz and Wolff's philosophy by introducing the expression 'Leibniz–Wolffian philosophy'.

[77] Tennemann calls empiricism and rationalism schools (e.g., 1798–1819, 10, p. 7; 11, p. 280).

[78] Tennemann 1816, pp. 328–9; 1798–1819, 11, p. 463. He is a sceptic in theoretical philosophy, but a dogmatist in philosophy of mathematics, aesthetics, ethics, and political philosophy (p. 428).

a 'counter-revolution' against Descartes' rationalism (1798–1819, 10, p. 493). For Tennemann, the first book of the *Essay* is an attack against Descartes, and especially against his theory of innate ideas, rather than innate principles (1798–1819, 11, pp. 20–1). Locke's empiricism gave rise to a rationalist counteroffensive, carried out by Leibniz in the *New Essays* (pp. 5–6).

With these internal developments and reciprocal oppositions, empiricism and rationalism underwent a proto-Hegelian dialectical development similar to the development sketched by Reinhold. Empiricism and rationalism are two antithetical and complementary viewpoints,[79] equally unilateral and unsatisfactory, that call for a higher synthesis. The limits of empiricism fuelled the development of rationalism and vice versa, but each movement proved incapable of satisfying human reason.[80] This became apparent when Hume revealed the sceptical consequences of Locke's empiricism. In doing so, Hume made philosophers aware of 'the necessity of a new direction, a deeper inquiry into the principles and laws of cognition' (Tennemann 1798–1819, 11, p. 519), 'a philosophy that is not unilateral and that fully satisfies reason' (p. 468). Kant was the first to develop such a philosophy, synthesising empiricism and rationalism into a higher system.

The political, social, religious, and broadly cultural context in which each philosophy arose rarely plays a major role in Tennemann's explanations. More important to him is the combination of three elements: the assumptions that each philosopher inherits from his predecessors, his polemical targets, and the originality with which he develops his ideas. Tennemann acknowledges that historians must take political, social, religious, and cultural factors into account, as well as the scientific developments of the time, and even what language philosophers were writing in.[81] This is because the development of a philosophy is not simply a necessary consequence of the shortcomings of his predecessors. Tennemann allowed for a greater degree of contingency in the history of philosophy than his proto-Hegelian narrative sometimes suggests (Santinello 1965, pp. 328, 332).

Although Tennemann's narrative stresses the internal continuity and reciprocal opposition of empiricism and rationalism, he also notes some cross-fertilisations and positive influences between the two movements. For instance, while Berkeley built his thought on Lockean assumptions, he attempted to avoid their sceptical consequences by developing an idealism that was 'prepared' (1816, p. 328) by Malebranche. Anticipating a theme later

[79] Tennemann's account of the dispute between Locke and Leibniz brings this out perspicuously (1798–1819, 11, p. 280).

[80] See, for example, Tennemann 1798–1819, 11, pp. 1–2, on how Descartes' and Spinoza's rationalism furthered the development of empiricism.

[81] Tennemann 1798–1819, 1, pp. xxiv, xxxvi–xxxvii, xliii, lviii–lxix.

developed by Luce and McCracken,[82] Tennemann places more emphasis on Berkeley's idealism and his affinity with Malebranche than on his empiricism.

On the whole, Tennemann's work attempts to balance two opposite tendencies. As a historian, he is committed to acknowledging the variety and contingency of historical facts, the originality of great thinkers, and the importance of external, non-philosophical factors in shaping their thought. As a philosopher, Tennemann aspires to show how reason is at work in history, singling out powerful, well-defined lines of development that transform every major thinker into an intermediate stage of reason's steady march towards the truth.

9.5 Conclusion: Biases and Choices

This chapter has reconstructed how the RED became widespread in Germany during the 1780s, how Reinhold made it the basis for a sketch of early modern philosophy that embodies the epistemological and Kantian biases, and how Tennemann developed Reinhold's sketches into a fully fledged Kantian history of seventeenth- and eighteenth-century philosophy. Tennemann's account is, in a number of ways, the archetype of traditional histories of early modern philosophy. Like them, Tennemann's history:

1. focuses on epistemological issues and, to a lesser extent, metaphysical issues, rather than natural philosophy, moral philosophy, or theology (epistemological bias);
2. assigns a central role to epistemological notions of empiricism and rationalism and categorises most early modern authors as either empiricists or rationalists (classificatory bias);
3. presents the development of empiricism and rationalism as a dialectical and teleological progression toward a higher point of view, namely, the Kantian synthesis and crowning of early modern thought (Kantian bias).

These features of Tennemann's account depend on three methodological choices:

1. reconstructing the history of philosophy in the Kantian sense;
2. privileging a historiographical narrative that portrays the progression of human reason towards Kant's philosophy, while assuming, with Reinhold, that this can best be done by employing the notions of empiricism and rationalism;
3. reading past philosophies backwards, from the privileged point of view of Kant's and Reinhold's philosophies, and tracing their ancestry in the early modern age.[83]

[82] Luce 1934; McCracken 1983, pp. 205–53.

[83] The alternative is reading past philosophies forwards, emphasising the way in which they derive from and relate to 'the period preceding and surrounding a given author' (Hatfield

What today's critics of the RED denounce as biases, not without reason, are conscious consequences of Tennemann's methodological choices. Tennemann is aware of a number of facts that are pointed out by the critics of the standard narrative. While he disregards natural philosophy in favour of epistemology, he acknowledges that many authors were not primarily epistemologists, but natural philosophers. While he applies the RED extensively, he is aware that some philosophers cannot be classified as empiricists or rationalists. While he contrasts empiricists and rationalists, he admits that there were some positive influences of the empiricists on the rationalists and vice versa. While he associates empiricism and rationalism with specific national characteristics,[84] he concedes that there were British rationalists such as Cudworth and Continental empiricists such as Gassendi.[85]

Tennemann appears to have underestimated the relevance of some of these facts, for instance the pervasiveness of the cross-influences between empiricism and rationalism.[86] He also made some historiographical mistakes, such as taking the first book of Locke's *Essay* to be primarily directed against Descartes.[87] While acknowledging these facts might have led Tennemann to qualify his account, it is unclear whether it would have led him to abandon a historiographical model based on the RED and the three biases. After all, they provided a powerful, wide-ranging interpretation of early modern philosophy that was in line with his conscious methodological choices.

Today, few would accept the Kantian assumptions that are at the basis of those choices and of Tennemann's picture of early modern philosophy. This, in itself, provides a reason to call into question the traditional accounts based on the RED. Once we reject their methodological underpinning, there may well be little point in retaining the traditional accounts, given the large amount of historiographical evidence that has been brought against them. Some have advocated retaining them on the ground that there are no persuasive alternatives (Kreimendahl 1998, p. 275). We believe that the history of experimental philosophy can provide a component of such an alternative – a new history of early modern philosophy.

When it first appeared, Tennemann's history was a new history of philosophy too. Tennemann was well aware that the writing of a new history of philosophy requires historians to make certain basic methodological choices: what notion of

2005, p. 106). To be sure, Tennemann reads past philosophies backwards as well as forwards, but reading them backward is what shapes his main narrative the most.

[84] On the background of this doctrine, see Piaia 1996.

[85] Tennemann 1798–1819, 10, p. 502 and p. 52.

[86] He does not highlight Bacon's influence on Descartes (Gäbe 1972, pp. 97–111); Descartes' on Locke (Loeb 1981); Gassendi's on Hobbes (Gueroult 1968, pp. 33, 39) and on Leibniz (Moll 1982); Hobbes' on Leibniz (Wilson 1997; G. M. Ross 2007); or Leibniz's on Hume (Engfer 1996, pp. 329–32).

[87] For a critique of this view, see Yolton 1956, chapter 2; Engfer 1996, pp. 184–90.

philosophy should they adopt? Should they be philosophically neutral or opinionated? Should they read the past forwards or backwards? Every history of philosophy reflects the way in which its writer answers those questions, whether consciously or not, and no amount of detailed factual scholarship, by itself, is sufficient to answer them. A new history of early modern philosophy might differ significantly in its main narrative from Tennemann's archetypal history. However, it should resemble it in relying on principled answers to the methodological questions that are raised by such an undertaking.

Conclusion

This study has shown that in the mid-seventeenth century, a new form of natural philosophy emerged in England. Its proponents called it experimental philosophy, and by the mid-eighteenth century, it was a Europe-wide phenomenon and arguably one of the most important approaches to the study of nature in the West. Our findings may be summarised as follows.

Experimental philosophy was characterised by the manner in which it prioritised experiment and observation over speculative theory and hypotheses in the derivation of knowledge of nature, and by its opposition to what it called speculative philosophy. To be sure, there were precedents in the late Renaissance for the shift in the epistemic credit rating of experience in the discipline of natural philosophy; however, it was not until the turn to experimentation in the precursor groups to the Royal Society in Oxford and London in the 1650s and, in particular, the development of Robert Boyle's natural philosophical methodology in the late 1650s, and the endorsement and promotion of this new methodology in the early Royal Society of London, that experimental philosophy was first established.

Once established, it began to flourish, and it soon became a multifaceted phenomenon: it became a movement amongst natural philosophers; it introduced new literary forms, such as the experimental report; and it took on a pedagogical dimension in the various lecture series on experimental philosophy in Oxford, Cambridge, and London in England, and St Andrews in Scotland; institutional niches emerged, such as the Plumian Chair in Astronomy and Experimental Philosophy in Cambridge established in 1707; a new vocabulary emerged including terms such as 'experimental philosopher', 'speculative philosopher', 'crucial experiment', 'experimental natural history', and 'experimental learning', and an associated material culture grew up around it.[1] As we have documented, some of these terms pre-dated the emergence of experimental philosophy, but these earlier uses are of interest

[1] As early as 1667, Sprat could comment on the appearance of experimental instruments in the shops of mechanics (Sprat 1667, p. 80), and by the eighteenth-century, cabinets of experimental philosophy were commonplace. See Bennett and Talas 2013.

largely because of the emergence of this new movement in natural philosophy in the late 1650s and 1660s.

Initially, the practitioners and theorisers of experimental philosophy sought to apply their prioritising of experiment and observation using the Baconian method of natural history. This was a new architectonic form of fact gathering and ordering founded on experimentation, direct observation, and testimony that would provide the basis for the future discovery of definitive principles on which a true natural philosophy could be established. However, by the 1690s this approach began to wane, and the new mathematical method of Newton emerged over the next few decades as a more powerful and promising alternative.

Moreover, once it was established, experimental philosophy soon spread throughout Britain and beyond. It was taken up in Italy in the 1660s, where there was already a tradition of experimentation in the work of Galileo, Torricelli, and their followers, and it had an early impact in France, though it would be decades before it took root there. Not only did experimental philosophy spread geographically, but its methods were also applied in disciplines other than natural philosophy: first in medicine and later in the moral sciences and even aesthetics. By the publication of Ephraim Chambers' *Cyclopaedia* in 1728, it could be said that '*Experiments*, within these 50 or 60 Years, are come into such Vogue, that nothing will pass in Philosophy, but what is founded on *Experiments*' (Chambers 1728, p. 368). By the late 1730s, experimental philosophy had been taken up wholesale in France, and in 1753, the first chair in experimental philosophy was established at the Collège de Navarre. In 1746, experimental philosophy, along with its contrast class, speculative philosophy, was enshrined in the very structure of a scientific academy in Europe: the revivified Prussian academy for the sciences and arts in Berlin established a class of experimental philosophy and a class of speculative philosophy. In fact, as late as 1775 Diderot was recommending in his plans for a new university in St Petersburg, Russia, that it include the teaching of experimental philosophy.[2]

In early eighteenth-century Germany, experimental philosophy heavily influenced the methodology of the dominant philosopher of the period, Christian Wolff, and by mid-century, it had a prominent role in the structure and outputs of the Berlin Academy. However, with the advent of Kantian philosophy and, in particular, Kant's own terms of reference for classifying various trends in the recent history of philosophy, the stock of experimental philosophy in Germany began to wane. Within a generation, Kant's followers Reinhold and Tennemann were propagating a new post-Kantian narrative about the leading schools of thought in the period since the Renaissance, and so was born the RED, which would eventually supplant the ESD and become

[2] Diderot 1875, p. 451.

the predominant terms of reference for understanding early modern philosophy from the turn of the twentieth century.

The evidence for these claims is extensive, indeed copious, and we have not come anywhere near to providing an exhaustive treatment of the materials available to document the emergence, nature, and impact of early modern experimental philosophy. Thus, for example, we have not discussed the impact of experimental philosophy on the Iberian peninsula in the eighteenth century, which has been a focus of the research of Juan Gómez.[3] Nor have we provided any detailed analysis of the spread of experimental philosophy in Italy in the latter half of the seventeenth century.[4] Clearly much work remains to be done, yet we believe that our history is robust enough both to sketch some facets of its legacy and to assess its implications for the historiography of early modern philosophy.

We turn first to the legacy of early modern experimental philosophy for the practice of science and for the philosophy of science. If early modern experimental philosophy has left one indelible mark on the practice of and theorising about modern science, it is the central role it accorded to experiment. One cannot recount the history of modern science since the eighteenth century without experiment having pride of place. Since the emergence of experimental philosophy in the seventeenth century, all science has been experimental science. To be sure, many theories have been or are contingently empirically intractable, but it is the very prospect of them becoming subject to experimental testing that urges scientists on. A theory that is in principle empirically intractable is not a scientific theory. Of course, this legacy of early modern experimental philosophy is not a solution to the demarcation problem between science and non-science, but it does set one ineliminable parameter in the framing of the problem: experiment provided an important new demarcation criterion for differentiating between science and non-science, and science and pseudo-science.[5]

Thus, many features of early modern experimental practice were developed and applied by later generations of practising scientists. Of course, some experimenters pre-dated or did not align themselves with the experimental philosophy movement, but early modern experimental philosophy provided the locus of the practices, instruments, and theories of much of the experimental science that was to influence the scientists of the nineteenth century and beyond. To take just one among countless examples, in microscopy there is a discernible continuity between Hooke's *Micrographia*, Buffon's

[3] See Gómez 2020. For suggestive leads on Francis Bacon's influence in Spain, Portugal, and Peru, see Hill 2000.

[4] See Vanzo 2016b, 2017, 2019.

[5] The literature on the demarcation problem is vast, but to our knowledge no one has made the connection between the problem of demarcation and early modern experimental philosophy.

experiments and reflections on the generation of animals, Robert Brown's description of Brownian motion, and Jean Perrin's experimental confirmation of Einstein's theory of Brownian motion.[6]

As for the philosophy of experiment, interestingly, some features of, say, the Bacon–Boyle–Hooke view have only been appreciated since the experimental turn in the philosophy of science in the late twentieth century. While the term 'crucial experiment' has been part of scientific parlance since Newton, exploratory experiments and the justification of repetition and replication of experiments were only 'discovered' in Boyle's writings with the benefit of hindsight in the 1990s.[7] Thus, while it is wrong to speak of a legacy here, there is no doubt that some of the salient features of contemporary philosophy of experiment were adumbrated in the mid-seventeenth century. A case in point is the interesting parallels between the use of queries by Fellows of the early Royal Society and those within its ambit, and the place of questions in the philosophy of science of David Glass and Ned Hall. Glass and Hall ask with respect to the biological sciences, 'how then might one frame the first experiment, before sufficient data are gathered to produce a model? ... It would seem that a question is the appropriate tool ... as opposed to a hypothesis' (Glass and Hall 2008, p. 380). They conclude '[the] building of hypotheses should be abandoned in favor of posing a straightforward question of a system and then receiving an answer, using that answer to model reality, and then testing the reproducibility and predictive power of the model, modifying it as necessary' (Glass and Hall 2008, p. 381).[8] Francis Bacon and his followers would have heartily concurred.

Turning to the question of historiography, over the last ten years or so, a number of scholars have attacked our work on early modern experimental philosophy and extolled the virtues of the continued deployment of the RED. Furthermore, in their work on frameworks, which is an attempt to complement the notion of historiographical terms of reference, Adrian Currie and Kirsten Walsh make a strong case for framework pluralism or ecumenism in the history and philosophy of science. In doing so, they use the dispute between the ESD and the RED as a pointed case study and claim 'prima facie, the dispute looks unproductive' (Currie and Walsh 2019, p. 25).[9] It is incumbent on us, therefore, in the conclusion of this volume to respond to both the defenders of the RED and to the novel frameworks theory of Currie and Walsh. We will do this by undertaking a comparative evaluation of early modern experimental philosophy and empiricism. The comparative evaluation will be set out using five categories: descriptions, historicity, scope, contrast classes, and explanatory power.

[6] See Hooke 1665; Lyon and Sloan 1981, pp. 165–209; R. Brown 1828; and Perrin 1910.

[7] See Sargent 1995 and Steinle 2016a, pp. 315–16. On the early stage of the experimental turn, see Hacking 1983, chapter 9; Franklin 1986; and Ackermann 1989.

[8] See also Glass 2014.

[9] In an earlier paper Walsh and Currie (2015) vigorously defend the ESD against the RED as a pedagogical tool for teaching early modern philosophy.

We argue that while there is significant overlap in their respective historiographical terms of reference or 'frameworks', empiricism has far less explanatory power and, in our view, no longer earns its keep. In short, there are historical phenomena that are highly relevant to its concerns but which either it cannot explain or its defenders have misconstrued.

Descriptions

Experimental philosophy in the first instance is a methodological approach for acquiring knowledge of nature that prioritises the use of experiment and observation over pre-existing theories or hypotheses in order to establish the foundations of a natural philosophy. In the early modern period, these foundations were understood to be natural philosophical principles from which theorems are demonstrated, theorems which together constitute a science or *scientia*. Those who accepted and applied the method of experimental philosophy called themselves experimental philosophers, and they were not opposed to the development of philosophical systems *simpliciter*. In fact, the development of a systematic natural philosophy was, in many cases, their ultimate goal. What they opposed was the construction of natural philosophical systems without adequate recourse to experiment and observation. Thus, those who advocated experimental philosophy normally opposed the method of developing a natural philosophy from a pre-existing theory or hypothesis that only paid lip service to experiment and observation. Experimental philosophers characterised this method as speculative philosophy.

Empiricism is a philosophical thesis about how humans acquire knowledge of the external world. It is the view that all of our concepts are acquired by experience and that all of our substantive knowledge can only be justified on the basis of experience.[10] At least, that is how we have chosen to describe empiricism here. The very nature of empiricism is contested, and there is a tendency in the history of the treatment of the thesis towards pluralism – towards many empiricisms – as we shall see in the section on scope below.[11] However, it seems safe to say that the prioritising of experience in acquiring knowledge of the world is a necessary constituent of any form of empiricism. What then of the role of reason in the acquisition of knowledge of the external world? Over the history of the use of this epistemological thesis, it has been very common to include the rejection of innate ideas and/or innate principles as a constituent doctrine of empiricism.

From these brief descriptions of experimental philosophy and empiricism, it is clear that the two overlap: both of them prioritise experience in the

[10] See Introduction, pp. 3–4, Vanzo 2016a, p. 253 and 2014, pp. 517–18.

[11] Peter Lipton's article on the history of empiricism goes so far as to claim, 'There are almost as many empiricisms as there are empiricists' (Lipton 2001, p. 4481).

acquisition of knowledge about the external world. Two respects in which they differ are that experimental philosophy is, in the first place, a method of knowledge acquisition that was *applied in natural philosophy* – later spreading to other disciplines – with a particular emphasis on the use of *experiments*, whereas empiricism is an abstract thesis that makes no claims about experiment or its relation to natural philosophy. Both experimental philosophy and empiricism are concerned with the justification of knowledge, though the former tends to focus on the epistemic adequacy of methods of knowledge acquisition, such as experimental replication and the reliability of instruments, and the role of observation and experiment in the establishment of principles, whereas the latter focuses on philosophical problems of knowledge justification, such as innatism and the problem of scepticism.

Historicity

Experimental philosophy is an actors' category: many early modern natural philosophers practised, theorised, and wrote about experimental philosophy and believed that it was an effective method for acquiring knowledge of nature. The method of experimental philosophy was self-consciously and openly employed by numerous natural philosophers from the 1660s until the late eighteenth century. There are books of experimental philosophy from the period, books that use the term 'experimental philosophy' and its cognates in their titles and within their pages, and books that criticise experimental philosophy. There are early modern lectures on experimental philosophy, courses on experimental philosophy, demonstrations of experimental philosophy, university lecturers and chairs of experimental philosophy, and in one case a class of experimental philosophy within a scientific institution. Needless to say, there is also a rich vocabulary associated with early modern experimental philosophy.

Empiricism, by contrast, is a historiographical category; it was not an actors' category in the early modern period in the sense described above. Empiricism did not have self-declared practitioners or theoreticians; there were no books published on the subject with the term 'empiricism' in their titles;[12] there were

[12] Ironically, in Joseph Priestley's *Philosophical Empiricism: containing Remarks on a Charge of Plagiarism respecting Dr H—s*, 1775, the term 'empiricism' is a term of abuse associated with Aristotle and Descartes (as well as Priestley's opponent, the chymist Bryan Higgins): 'These and suchlike long-exploded, and crude notions (so many of which I believe were never thrown together into the same compass since the age of Aristotle or Cartesius) are delivered in a manner and phrase so quaint, and a tone so solemn and authoritative, as gives me an idea that I cannot express otherwise than by the term *Philosophical Empiricism*' (Priestley 1775, p. 59). This is the only association of the term 'empiricism' with philosophy that we have found in English literature prior to the publication of Kant's *Critique of Pure Reason* in 1781. As far as we are aware, 'empiricism' first took up

no empiricist institutional niches, lectures, demonstrations, or associated vocabulary.[13]

Of course, the fact that experimental philosophy was an actual historical phenomenon does not automatically give it a privileged role as a historiographical category or framework for the study of early modern philosophy and science. To be sure, actors' categories, such as the Renaissance and *siècle des lumières*, have provided fertile terms of reference for understanding particular movements in the history of the arts or intellectual history. And indeed, actors' categories often have advantages when used as historiographical terms of reference over anachronistic categories, though it should not be presumed that this is always the case.

Scope

The scope of experimental philosophy expanded over time both in its nature and in the disciplinary domains to which it was applied. Experimental philosophy began as a *method* for acquiring knowledge in natural philosophy through the use of experiment and observation, and as more and more natural philosophers took it up, it became a *movement*. As it gained success and was seen to generate new knowledge, the knowledge that it generated came also to be called experimental philosophy, and the replication, or demonstration, of experiments that generated that knowledge came to be called experimental philosophy. Thus, a *disciplinary* sense was added to the semantic domain of the term 'experimental philosophy'. This disciplinary sense of the term was carried over into the names of university positions in experimental philosophy such as lecturers and chairs.

Furthermore, such was the perceived success of this new approach to natural philosophy that some sought to apply the method beyond the discipline in which it originated to other fields such as medicine and the moral sciences. Thus, while the emphasis on experiment never receded, the domain of application of the method was greatly expanded as the eighteenth century unfolded.

Empiricism as a historiographical category also illustrates important changes in scope. The primary focus on empiricism in Part III of this book has been on the post-Kantian notion of empiricism that was paired with rationalism and set within the context of the Kantian bias and the two triumvirates of Locke, Berkeley, and Hume and Descartes, Spinoza, and

a positive connotation in the English literature in a review of a pamphlet on Kant which was published in 1795. See Micheli 1990, p. 243.

[13] This has not prevented proponents of the RED from writing as if rationalism and empiricism were actual historical doctrines. Michael Ayers, for example, says 'There really was a choice facing new philosophers, reasonably described as a choice between Rationalism and Empiricism, but there was also the possibility of deliberate eclecticism or synthesis' (Ayers 1998, p. 1029).

Leibniz. It is empiricism within this broader historiographical context that had the greatest bearing on the history, indeed the fate, of early modern experimental philosophy. However, the empiricism under consideration here, that is, the form of empiricism defended by today's critics of the ESD, is far narrower: it is restricted to the epistemological bias and has little to say about either the Kantian bias or the classificatory bias.

More importantly, the issue of scope pertains to the tendency of empiricism towards pluralism, and it is worth setting out some examples here. Even a cursory survey of scholarship on early modern philosophy reveals a tendency amongst scholars to develop typologies of the historiographical category empiricism. For example, Jonathan Bennett, a leading commentator on early modern philosophers who works with the RED historiography, claims that there are two forms of empiricism, concept-empiricism and meaning-empiricism, in his volume on the triumvirate Locke, Berkeley, and Hume.[14] Michael Ayers in his widely acclaimed *Locke: Epistemology and Ontology* (1991) argues that there are two pairs of empiricism in Locke, namely, knowledge-empiricism and concept-empiricism, and ontological versus epistemological empiricism.[15] The Hume scholar Don Garrett, in his influential *Hume on Cognition and Commitment* (1997), gives us a fivefold division of empiricisms. He argues that in the early modern period, there were *methodological*, *conceptual*, *nomological*, *explanatory*, and *reductive* empiricisms.[16] Jonathan Lowe gives us a tripartite division into *scientific*, *genetic* (of which there are two subspecies), and *analytic*.[17]

It is hardly surprising, therefore, to find two of our critics, Zvi Biener and Eric Schliesser, arguing for significant diversity in the notion of empiricism:

> Our contemporary 'empiricism' refers to a mélange of related ideas that privilege experience, but in manners diverse and often indirect. These ideas may be overtly semantic or epistemological (concerning the origin of mental contents or the ultimate sources of justification), but they can also be methodological (concerning the proper method of discovery and use of evidence), practical and technological (concerning rules-of-thumb or procedures for developing knowledge through real-world manipulation, but also real-world manipulation for non-epistemic, e.g., medical ends), or political and moral. (Biener and Schliesser 2014, pp. 2–3)

What is surprising is the extension here of the meaning of 'empiricism' to cover methods of discovery and 'procedures for developing knowledge'. In our

[14] Jonathan Bennett 2001, pp. 3 and 359. Bennett used 'meaning-empiricism' in his earlier *Locke Berkeley Hume* (Bennett 1971, pp. 26, 44, 223).
[15] Ayers 1991, 1, pp. 14–15 and 2, p. 156, respectively. See chapter 13 for the full-blown RED at work.
[16] Garrett 1997, pp. 29–38.
[17] Lowe 1995, pp. 32–3.

view, Biener and Schliesser are following the trend, whether consciously or not, in the history of science over the last two decades of extending the semantic range of the historiographical category 'empiricism' to cover the load that is normally borne by the (non-historiographical) adjective 'empirical'. Historians of early modern science, such as Pamela Smith and Gianna Pomata, took the term 'empiricism' in a new direction: for them, it no longer functions merely as a historiographical category but now refers to actual methods of knowledge generation.[18] This is confirmed by Schliesser's later chapter on four methods of empirical enquiry (Schliesser 2018), which he originally cites as 'four kinds of empiricism'.[19] His four kinds of empiricism are the mathematical-experimental method, the method of experimental series, the method of inspecting ideas, and the method of natural history.

Note the parallels between his four methods of 'empiricism' and the history of experimental philosophy as expounded in this book: mathematical-experiment, experimental series, inspecting ideas, and natural history are all features of early modern experimental philosophy, now corralled under the 'mélange of related ideas' that make up empiricism. Is there any explanatory advance achieved by claiming that empirical methods are referents of 'empiricism'? This smacks of a post hoc attempt to stretch the term 'empiricism' to cover the phenomenon of early modern experimental philosophy. It is an exercise in redefining a term in order to save its explanatory adequacy in the face of a serious rival and in response to the realisation that the traditional historiographical notion of empiricism (with its epistemological focus) failed to capture a significant range of historical developments in which experience was central. Yet Biener and Schliesser, and others, go further and claim that there are distinct advantages to using the category of empiricism instead of experimental philosophy. In order to understand their arguments, we need now to turn to the contrast classes of experimental philosophy and empiricism, namely speculative philosophy and rationalism.

Contrast Classes

Many experimental philosophers set themselves against speculative philosophy, that is, the method in natural philosophy that commences inquiry from a philosophical system or hypothesis that has not itself been established with adequate appeal to experiment and observation. It is tempting to think of speculative philosophy as a substantive rival of experimental philosophy,

[18] For an overview, see P. Smith 2009, pp. 361–4; for recent collections, see Pomata and Siraisi 2005 and Smith, Meyers, and Cook 2014, Wolfe and Gal 2010a and 2010b; for a critique, see Young 2017b.

[19] Biener and Schliesser 2014, p. 3 n. 6 and p. 11 for the original title. For another example of this pluralist trend in the history of early modern philosophy, see Wolfe 2010.

a kind of obverse method that itself formed a movement and had outputs and other material manifestations in the manner of experimental philosophy. However, as we have documented, this is far from the situation in the early modern period. Four features of speculative philosophy need to be borne in mind when it is taken as a contrast class to experimental philosophy. First, it is a residue of the age-old distinction, discussed in Chapter 1, between the practical and speculative sciences. Natural philosophy had for centuries been a speculative science, so when experimental philosophy emerged in the mid-seventeenth century, it defined itself, in part, in contradistinction to its former self, so to speak. That is, it defined itself as distinct from natural philosophy as a speculative science.

Second, and as a consequence of the first consideration, sometimes speculative philosophy is spoken of as a method and at other times it is spoken of as the content or doctrines derived from that method. Thus, Aristotelianism and Cartesianism were often described as systems of speculative philosophy. Moreover, often the adjective 'speculative' is used as a synonym for 'theoretical', and this is the case for Boyle, who wrote about the mutual benefits of the experimental and 'theorical' or speculative parts of natural philosophy.[20] Here the point is that 'speculative' is used in a generic contrast between experiment and theory. Third, in the early modern period very few natural philosophers openly aligned themselves with speculative philosophy and against experimental philosophy. Nevertheless, among those thinkers who critiqued experimental philosophy, this was often done using speculative philosophy as a contrast class. One thinks of Margaret Cavendish as a prime example. And this brings us to the fourth consideration, which is that there was no movement of speculative philosophers: there was no 'group of people working towards a shared goal' – as the OED defines 'movement'; rather, there were leading speculative systems that had numerous, nameless adherents, individuals who developed their own speculative systems, and individuals whose views were disparagingly referred to as speculative, even though some of them did grant meaningful roles to experience.

This lack of parity between experimental philosophy and speculative philosophy marks a significant difference between the ESD and the RED. For in the case of empiricism, there is a substantive contrasting philosophical thesis, namely rationalism. Rationalism is here defined as the view that we have non-empirical concepts and some substantive knowledge can be justified a priori. The most important example of rationalists from the period are those philosophers who claimed that humans are born with innate principles from which natural philosophical knowledge can be derived. In fact, innatism, whether it be about principles or ideas, has sometimes been regarded as a necessary

[20] For other examples of disciplinary uses of 'speculative', see the works quoted at p. 5, n. 15 and the structure of the Berlin Academy, discussed in Section 7.4.

condition of rationalism. According to the standard RED historiography, in the early modern period there were both empiricists and rationalists, most notably the three triumvirates, and therefore, empiricism and rationalism were on a par. And yet this, together with the inclusion of innatism, has led to problems with the classificatory bias.[21]

This brings us to a recent criticism of Siegfried Bodenmann and Anne-Lise Rey. They reject the ESD because it is merely 'one of many ways to cite experience in the process of knowing' and because it 'replaces an established duality with a new one' (Bodenmann and Rey 2018b, p. 6). They continue:

> The first problem with these dualities is that they suggest two completely distinct traditions: different groups of actors, with different principles and ways of thinking, each of them cohesive and homogeneous . . . One only needs to look at some of the most renowned eighteenth-century empiricists like Maupertuis, d'Alembert, Emilie du Châtelet, Boerhaave, 's Gravesande, Musschenbroek, or Haller to understand that they were far from embodying a simple rejection of metaphysics and rationalism.[22]

Yet, as should be clear from the evidence adduced in this book, speculative philosophy always lacked parity with experimental philosophy: it was not a movement, did not have many advocates, and in some polemical contexts, it is virtually a strawman. Nor, might we add, were all experimental philosophers opposed to metaphysics. Moreover, some experimental philosophers argued for the mutual benefits of the speculative and experimental. And some authors did endorse a priori systems in ways that were in tension with their commitment to experimental philosophy.

Explanatory Power

To what extent does each of these ostensibly competing historiographical terms of reference, the ESD and the RED, enable us better to understand the nature of the important changes and advances that early modern natural philosophy underwent in the seventeenth and eighteenth centuries? It will hardly surprise the reader to learn that in our view the historical phenomenon that was experimental philosophy, together with its contrast class speculative philosophy, has greater explanatory reach and leads to more nuanced interpretations and a deeper understanding of early modern natural philosophy, and some aspects of early modern thought in general, than the RED. Perhaps the most effective way to establish this claim is by way of examples.

A first example derives from another criticism of Biener and Schliesser. They claim that a distinct advantage of working with the notion of empiricism

[21] See Chapter 8, pp. 236, 246–9 above.
[22] For a similar criticism, see Dobre and Nyden 2013b, pp. 7–8.

rather than experimental philosophy, at least from the time of Newton, is that it enables us to account for the fact that, in addition to being a self-declared experimental philosopher, Newton put forward his own system, something that would have been frowned upon by earlier generations of experimental philosophers. However, as we have argued, far from rejecting natural philosophical systems outright, experimental philosophers actually aspired to establish the definitive natural philosophical system. Henry Oldenburg is just one among many who claimed that the project of natural history 'can provide materials sufficient to build an unshakeably firm system of philosophy' (*Oldenburg Corr.*, 2, p. 144).[23]

Moreover, as it happens, anti-system sentiment actually increased in the eighteenth century, particularly in France, most famously in the writings of Condillac, who, as Ellen Hine argued many years ago,[24] was not opposed to systems *simpliciter*, and in fact plumped for a system based upon principles such as Newtonian gravity.[25] Far from providing a reason for preferring empiricism over experimental philosophy as an explanatory or organising historiographical category for understanding eighteenth-century natural philosophy, Biener and Schliesser, in our view, have misunderstood the nature of the anti-system sentiment that characterised many early modern experimental philosophers. That misunderstanding is likely to arise from the limits of the RED framework, and this, in spite of their claim that 'the term "empiricism" does not obscure any insight that might be gained from a careful study' of early modern 'cultures of taking experience seriously' (Biener and Schliesser 2014, p. 5).

A second, closely related example is the pervasive anti-hypotheticalism that we have documented in the preceding chapters. It is evident from the numerous discussions from the 1960s until the present of, say, Newton's attitude to hypotheses that the RED gets little purchase on this issue, and yet the role of hypotheses in the acquisition and justification of knowledge of nature is highly relevant to the doctrine of empiricism. Ernan McMullin's discussion is a case in point. Using rationalism and empiricism as his terms of reference, calling them 'the two "classical" forms of philosophy of science originating in the seventeenth century' (1976, p. 395), he sets the problem up in the following manner: 'After a century in which hypothesis and forms of inference less direct than deduction and inductive generalization had been widely accepted among those who charted the course of the new sciences, Newton's admonitions [against hypotheses] seemed to strike a discordant note' (McMullin 2001, p. 280).

[23] See also Oldenburg's defence of 'the Experimental way of Philosophy' in M. Hunter 1989b, p. 68, quoted on p. 56 above.
[24] Hine 1979.
[25] See his *Treatise on Systems* in Condillac 1982, p. 3.

On McMullin's analysis, Newton's rejection of hypotheses in natural philosophy is problematic in the light of the empiricists that precede him, and it is this that he is at pains to explain.[26] Clearly, this is misconceiving the historical evidence and the central philosophical problem that early modern philosophers discussed in relation to hypotheses. By contrast, using the ESD as our terms of reference, the explanation is readily at hand: Newton's *hypotheses non fingo* is echoing a widely held sentiment of experimental philosophers who oppose speculative philosophy and the way it uses hypotheses.[27] This interpretation is very naturally reinforced by examining his correspondence with Roger Cotes when he (Newton) brands Leibniz a hypothetical philosopher around the time that he was composing the 'General Scholium',[28] and then later in his 'An Account of the Book Entitled *Commericum Epistolicum*'.[29] Likewise, when we examine precursors to Newton's 'I feign no hypotheses' – Newton had been speaking of feigning hypotheses at least from 1704[30] – from many decades before the 'General Scholium', we again find the usual rhetoric of experimental philosophy against speculative hypotheses.[31] Indeed this anti-hypothetical sentiment spread beyond natural philosophy. So, for example, John Toland, who was later to become a Newtonian, in his *Christianity Not Mysterious*, famously claimed 'I banish all HYPOTHESES from my PHILOSOPHY' (Toland 1696, p. 15).

In our view, the examples of the attitude to systems and the status of hypotheses in natural philosophy are clear points at which the ESD has explanatory superiority over the RED. Yet Biener and Schliesser offer still another reason for preferring the RED over the ESD; they claim that the RED is actually better at explaining the trajectory that philosophy took after Kant and, in particular, the state of epistemology and the philosophy of science today. They speak of philosophy's 'self-constructed narrative history' and want to know 'what Newton actually had to do with what eventually became known as "empiricism"' (Biener and Schliesser 2014, p. 5). The implicit argument is that many contemporary philosophers call themselves empiricists and the RED is better at explaining why this is the case than the ESD. What are we to make of this?

We believe that the history of experimental philosophy set out in the preceding pages, when complemented by recent work on the history of empiricism up to 1915,[32] provides a far fuller and more nuanced historical

[26] See also McMullin 1985, esp. pp. 33–4.
[27] For further discussion, see Anstey 2005, pp. 232–7.
[28] *Newton Corr.*, 5, pp. 398–9, cited above at p. 137.
[29] See Newton 1715, p. 224, cited above on pp. 139–40.
[30] See the manuscript transcribed in McGuire 1970, p. 185.
[31] See, for example, Sir Robert Moray cited above at p. 53, Glanvill 1665, sig. B4^{r-v}, and Samuel Parker 1666, pp. 45–6, cited at p. 77 above.
[32] See Vanzo 2014, 2016a.

explanation than can be hoped for from the RED as to why many philosophers of the twentieth century and beyond call themselves empiricists or rationalists. A parallel consideration brings home the point. It may be tempting for a practitioner of contemporary x-phi to claim a lineage back to Boyle, Newton, and Hume; after all, were they not also experimental philosophers? However, we urge caution in making any such direct associations, because while some of the core terminology is the same, early modern experimental philosophy is only a distant ancestor of contemporary x-phi: there are many discontinuities between them.[33] Moreover, in our view it is unlikely that many contemporary philosophers who call themselves empiricists would regard the broader 'mélange of related ideas' that Biener and Schliesser now identify as empiricism as philosophically substantive, let alone identify with it. Their approach seems to founder between the Scylla of the restricted sense of 'empiricism' being merely historiographical and the Charybdis of the broader sense that has not much relevance to contemporary empiricist philosophers.

Any adequate historical explanation as to why there are now philosophers who call themselves empiricists should now refer to the nature, scope, and philosophical importance of early modern experimental philosophy and its obscuring at the hands of the post-Kantian RED. In fact, we argue that even today, the relative neglect of early modern experimental philosophy results from the dominance of the RED in both the undergraduate philosophy curriculum and within advanced scholarship on early modern philosophy.

In the light of these considerations, we believe that the ESD is explanatorily superior to the RED as a framework for understanding early modern natural philosophy. We also take the tendency of empiricism to proliferate in the hands of historians of early modern philosophy and the history of science to be a sign that the notion, together with its contrast class of rationalism, no longer earns its keep. This is not to deny that the RED has served us well in the past. This is not to call for a blanket prohibition on the use of the RED by historians and teachers of early modern philosophy. It is rather an appeal to our readers carefully to consider whether the RED has passed its use-by date and should now find its home as a case study in courses in historiography. Whatever the fate of these post-Kantian categories, it is our sincere hope that from now on the ESD will yield still more insights into the history of early modern thought.

[33] See Anstey and Vanzo 2016, pp. 98–9 and Vanzo 2018.

MANUSCRIPTS CITED

Bodleian Library, Oxford
Bodleian Add. MS C. 272
MS Bradley 1
MS Bradley 12
MS Bradley 48
MS Radcliffe Trust d. 9
British Library
British Library Add. MS 32545
British Library Add. MS 32546
Cambridge University Library
Cambridge University Library MS Add. 3958
Cambridge University Library MS Add. 3968
Christ Church, Oxford
Christ Church MS 131
Fitzwilliam Museum, Cambridge
Fitzwilliam Notebook
Foyle Special Collections Library, King's College London
Wheatstone Collection QC19 COT
Royal Society of London
Royal Society Boyle Papers, vol. 9
Royal Society Boyle Papers, vol. 10
Royal Society Boyle Papers, vol. 21
Royal Society Classified Papers, 20/42
Royal Society Classified Papers, xx.80
Royal Society Journal Book, vol. x1
University of Manchester
University of Manchester Library GB 133 Eng MS 1494
University of Sheffield
The Hartlib Papers, eds. M. Greengrass, M. Leslie, and M. Hannon (2013). Published by The Digital Humanities Institute, University of Sheffield, available at www.dhi.ac.uk/hartlib
Yale University
Beineke Library Osborn fc95

NEWSPAPERS, BROADSHEETS, AND ALMANACS

Mercure Galant, Paris
Mercurius Oxoniensis; or, The Oxford Intelligencer, For the Year of our Lord 1707, London
Pax, Pax, Pax, a Pacifick Post Boy, London, cited from Harry Ransom Center, University of Texas, Austin
Proposals for an annual course in experimental philosophy at St Salvator's College, University of St Andrews, Scotland, 1700
The Compleat Library, or, News for the Ingenious, cited from British Periodicals Collection II, ProQuest.
The Daily Courant, London, cited from the Burney Newspapers Collection, Gale Primary Sources
The Examiner, London, cited from British Periodicals Collection II, ProQuest
The Oxford Almanack for the Year of our Lord God 1703, Oxford
The Post Boy, London, cited from the Burney Newspapers Collection, Gale Primary Sources

REFERENCES

Aaron, Richard I. (1971) *John Locke*, 3rd ed., Oxford: Clarendon Press.

Aarsleff, Hans (1989) 'The Berlin Academy under Frederick the Great', *History of the Human Sciences*, 2, pp. 193–206.

Abel, Jacob Friedrich (1784) *Allgemeine Einleitung von dem Nuzen der Menschenkenntniß*, in Abel 1784–90, vol. 1, pp. i–xxx.

(1784–90) *Sammlung und Erklärung merkwürdiger Erscheinungen aus dem menschlichen Leben*, Frankfurt.

(1786) *Einleitung in die Seelenlehre*, Stuttgart.

(1995) *Eine Quellenedition zum Philosophieunterricht an der Stuttgarter Karlsschule (1773–1782)*, ed. Manfred Riedel, Würzburg: Königshausen & Neumann.

(1995 [1773]), 'Schreiben an Herzog Carl Eugen von Württemberg über die Neugestaltung des Philosophieunterrichts auf der Solitude: Nebst einem "Entwurf zu einer Generalwissenschaft oder Philosophie des gesunden Verstandes zur Bildung des Geschmacks, des Herzens und der Vernunft"', in Abel 1995, pp. 15–23.

Abel, Jacob Friedrich and Schwab, Johann Christoph (1778) 'Gründe, warum die bißher in der Carls-Akademie üblich gewesene Ordnung, die philosophische Disciplinen vorzutragen, in etwas abgeändert worden ist, auf gnädigsten Befehl Seiner Herzoglichen Durchlaucht vorgelegt, von den Professoren der Philosophie Abel und Schwab', in Abel 1995, pp. 397–9. Undated manuscript, probably written in 1778 or shortly afterwards.

Abercrombie, David (1687) *Academia Scientiarum, or, The Academy of Sciences being a Short and Easie Introduction to the Knowledge of the Liberal Arts and Sciences*, London.

Ablondi, Fred (2012) 'James Beattie, practical ethics, and the human nature question', *Journal of Scottish Philosophy*, 10, pp. 1–12.

Accademia dei Fisiocritici (1691) 'Costituzioni dell'Accad[emi]a fisico-medica detta l'Accademia dei Fisiocritici eretta in Siena l'anno 1691', *Archivio storico dell'Accademia dei Fisiocritici*, Atti 2.34, https://bit.ly/3V8PlDU. Paginated by hand.

Accademia di scienze, lettere ed arti (1780) *Statuto dell'accademia di scienze, lettere, ed arti di Padova*, Padua.

Ackermann, Robert (1989) 'The new experimentalism: Review of Allan Franklin, *The Neglect of Experiment*', *British Journal for the Philosophy of Science*, 40 (2), pp. 185–90.

Acosta, José de (1590) *Historia natural y moral de las Indias*, Seville.

Adickes, Erich (1897) 'Die bewegenden Kräfte in Kants philosophischer Entwicklung und die beiden Pole seines Systems', *Kant-Studien*, 1, pp. 9–59, 161–96, 352–415.

Agricola, Georgius (1556) *De re metallica libri* XII, Basel.

Agrippa, Heinrich Cornelius (1533) *De occulta philosophia, libri tres*, Cologne.

Ahnert, Thomas (2003) 'Nullius in verba: Autorität und Experiment in der Frühen Neuzeit: Das Beispiel Johann Christoph Sturms (1635–1703)', *Zeitsprünge*, 7 (1), pp. 604–18.

(2004) 'Newtonianism in early Enlightenment Germany, c. 1720 to 1750: metaphysics and the critique of dogmatic philosophy', *Studies in History and Philosophy of Science*, 35, pp. 471–91.

Albertus Magnus, Pseudo- (1483) *Liber aggregationis seu liber secretorum Alberti Magni*, 2nd ed., London.

(1974) *The Book of Secrets of Albertus Magnus of the Virtues of Herbs, Stones and Certain Beasts, also a Book of the Marvels of the World*, eds. Michael R. Best and Frank Brightman, Oxford: Clarendon Press.

D'Alembert, Jean Le Rond (1743) *Traite de dynamique*, Paris.

(1749) *Recherches sur la précession des equinoxes, et sur la nutation*, Paris.

(1756) 'Expérimental', in *Encyclopédie*, vol. 6, eds. Denis Diderot and Jean Le Rond d'Alembert, Paris, 1751–72, pp. 298–301.

(1965 [1759]) *Essai sur les éléments de philosophie*, Hildersheim: Olms.

(1995 [1751]) *Preliminary Discourse to the Encyclopedia of Diderot*, trans. R. N. Schwab, Chicago: University of Chicago Press.

D'Alembert, Jean Le Rond and La Chappelle, Jean-Baptiste de (1755) 'Elemens des sciences', in *Encyclopédie*, vol. 5, eds. Denis Diderot and Jean Le Rond d'Alembert, Paris, 1751–72, pp. 491–7.

Aletino, Benedetto [Giovanni Battista De Benedictis] (1694) *Lettere apologetiche in difesa della Teologia Scolastica, e della Filosofia Peripatetica*, Naples: Raillard.

Alexander, H. G. ed. (1956) *The Leibniz–Clarke Correspondence: Together with Extracts from Newton's* Principia *and* Opticks, Manchester: Manchester University Press.

Allison, Henry E. (2004) *Kant's Transcendental Idealism: An Interpretation and Defense*, 2nd ed., revised and enlarged, New Haven: Yale University Press.

Alsted, Johann Heinrich (1630) *Encyclopædia*, Herborn.

Altieri Biagi, Maria Luisa and Basile, Bruno (1980) *Scienziati del Seicento*, Milan: Ricciardi.

Ameriks, Karl (2000) *Kant and the Fate of Autonomy*, Cambridge: Cambridge University Press.

(2004) 'Reinhold über Systematik, Popularität und die "Historische Wende"', in Bondeli and Lazzari 2004, pp. 303–33; trans. in Karl Ameriks, *Kant and the Historical Turn: Philosophy as Critical Interpretation*, Oxford: Oxford University Press, 2006, pp. 185–206.

Andrade, E. N. da C. (1950) 'Wilkins Lecture: Robert Hooke', *Proceedings of the Royal Society, Series B*, 137, pp. 153–87.

Anon. (1665) 'Enquiries concerning agriculture', *Philosophical Transactions*, 1.5, pp. 91–4.

(1677) 'Review of Robert Plot, *The Natural History of Oxfordshire*', *Philosophical Transactions*, 12.135, pp. 875–9.

(1679) *Catalogue des livres de feu Mr Briot*, Paris.

(1688) 'Review of Isaac Newton, *Philosophia naturalis principia mathematica*', *Journal des sçavans*, 2 August, pp. 237–8.

(1700) *Proposals for an Annual Course of Experimental Philosophy*, Edinburgh [?].

(1710) 'Review of John Freind, *Prælectiones chymicæ*', *Acta Eruditorum*, 9, pp. 412–16.

(1716) 'Review of G. Gazola, *Il mondo ingannato da' falsi Medici*', *Giornale de' letterati d'Italia*, 27, pp. 214–69. Actually published in 1717.

(1719) *Dictionnaire Royal, Anglois-François, et François-Anglois*, vol. 2, Amsterdam.

(1727) *A Course of Mechanical and Experimental Philosophy*, London.

(1751) *Dictionnaire philosophique ou introduction à la connoissance de l'homme*, London.

(1763) *État ou Tableau de la ville de Paris, nouvelle édition*, Paris.

(1765) 'Système', in *Encyclopédie*, vol. 15, eds. Denis Diderot and Jean Le Rond d'Alembert, Paris, 1751–72, pp. 777–8.

(1783) 'Review of Immanuel Kant, *Prolegomena zu einer jeden künftigen Metaphysik, die als Wissenschaft wird auftreten können*', *Neueste kritische Nachrichten* (Greifswald), 31 August.

(1787) 'Review of Johann Georg Heinrich Feder, *Ueber Raum und Caussalität*', *Neue Leipziger Gelehrte Zeitungen*, pp. 2039–45, 2054–61.

(1790) 'Review of Ernst Platner, *Neue Anthropologie*', *Göttingische Anzeigen von gelehrten Sachen*, 158, pp. 1577–86.

Anstey, Peter R. (2002) 'Robert Boyle and the heuristic value of mechanism', *Studies in History and Philosophy of Science*, 33, pp. 161–74.

(2004) 'The methodological origins of Newton's queries', *Studies in History and Philosophy of Science*, 35, pp. 247–69.

(2005) 'Experimental versus speculative natural philosophy', in Anstey and Schuster 2005, pp. 215–42.

(2011a) *John Locke and Natural Philosophy*, Oxford: Oxford University Press.

(2011b) 'The creation of the English Hippocrates', *Medical History*, 55, pp. 457–78.

(2012) 'Francis Bacon and the classification of natural history', *Early Science and Medicine*, 17, pp. 11–31.

Anstey, Peter R., ed. (2013a) *The Oxford Handbook of British Philosophy in the Seventeenth Century*, Oxford: Oxford University Press.

Anstey, Peter R. (2013b) 'John Locke on the understanding', in Anstey 2013a, pp. 311–28.

(2013c) 'The theory of material qualities', in Anstey 2013a, pp. 240–60.

(2014a) 'Philosophy of experiment in early modern England: the case of Bacon, Boyle and Hooke', *Early Science and Medicine*, 19, pp. 103–32.

(2014b) 'D'Alembert, the "Preliminary Discourse" and experimental philosophy', *Intellectual History Review*, 24, pp. 495–516.

(2015) 'Experimental pedagogy and the eclipse of Robert Boyle in England', *Intellectual History Review*, 25, pp. 115–31.

(2016) 'The coherence of cohesion in the later Leibniz', *British Journal for the History of Philosophy*, 24, pp. 594–613.

Anstey, Peter R., ed. (2017a) *The Idea of Principles in Early Modern Thought: Interdisciplinary Perspectives*, New York: Routledge.

Anstey, Peter R. (2017b) 'Experimental philosophy and the principles of natural religion, 1667–1720', in Anstey 2017a, pp. 246–70.

(2018) 'The principled Enlightenment: Condillac, d'Alembert and principle minimalism', in *Rethinking the Enlightenment: Between History, Philosophy, and Politics*, eds. Geoff Boucher and Henry Martyn Lloyd, Lanham: Lexington, pp. 131–50.

(2019) 'Santayana's Locke', *Limbo*, 39, pp. 27–46.

(2020) 'Principles in early modern philosophy and science', in Jalobeanu and Wolfe 2020.

(2022) 'The four classes of the Berlin Academy', in *The Berlin Academy in the Reign of Frederick the Great: Philosophy and Science*, eds. Tinca Prunea-Bretonnet and Peter R. Anstey, Oxford University Studies in the Enlightenment, Liverpool: Liverpool University Press, pp. 17–38.

Anstey, Peter R. and Hunter, Michael (2008) 'Robert Boyle's "Designe about Natural History"', *Early Science and Medicine*, 13, pp. 83–126.

Anstey, Peter R. and Jalobeanu, Dana (2022) 'Experimental natural history', in *The Cambridge History of Philosophy and the Scientific Revolution*, eds. David Marshall Miller and Dana Jalobeanu, Cambridge: Cambridge University Press, pp. 222–37.

Anstey, Peter R. and Schuster, John A., eds. (2005) *The Science of Nature in the Seventeenth Century: Patterns of Change in Early Modern Natural Philosophy*, Dordrecht: Springer.

Anstey, Peter R. and Vanzo, Alberto (2012) 'The origins of early modern experimental philosophy', *Intellectual History Review*, 22, pp. 499–518.

(2016) 'Early modern experimental philosophy', in *A Companion to Experimental Philosophy*, eds. Justin Sytsma and Wesley Buckwalter, Oxford: Blackwell, pp. 87–102.

Antognazza, Maria Rosa (2004) 'Review of Steven Nadler, ed., *A Companion to Early Modern Philosophy*', *Philosophical Quarterly*, 54, pp. 473–6.

Aquinas, Thomas (1999 [1265–74]) *Summa theologiæ*, Cinisello Balsamo: San Paolo, 3rd ed.; trans. by the Fathers of the English Dominican Province as *Summa theologica*, London: Oates & Washbourne, 1920–4.

Ariew, Roger and Grene, Marjorie (1999) 'The Cartesian destiny of form and matter', in Roger Ariew, *Descartes and the Last Scholastics*, Ithaca: Cornell University Press, pp. 77–96.

Aristotle (1984) *The Complete Works of Aristotle: The Revised Oxford Translation*, 2 vols., ed. Jonathan Barnes, Princeton: Princeton University Press.

Arnauld, Antoine and Nicole, Pierre (1996 [1683]) *Logic or the Art of Thinking*, ed. Jill Vance Buroker, Cambridge: Cambridge University Press. 5th French ed. 1683.

Arndt, Hans Werner (1962) 'Einführung', in Wolff 1962 [1754], pp. 7–102.

(1986) 'Rationalismus und Empirismus in der Erkenntnislehre von Christian Wolff', in *Christian Wolff: 1679–1754: Interpretationen zu seiner Philosophie und deren Wirkung*, ed. Werner Schneiders, 2nd ed., Hamburg: Meiner, pp. 31–47, repr. in Wolff 1962–, sect. 3, vol. 65, pp. 11–27.

Ashworth, William B. Jr (1990) 'Natural history and the emblematic world view', in Lindberg and Westman 1990, pp. 303–32.

Aubrey, John (1847) *The Natural History of Wiltshire*, ed. John Britton, London: Wiltshire Topographical Society.

(2000 [1681]) *Brief Lives*, ed. John Buchanan-Brown, Harmondsworth: Penguin.

Austen, Ralph (1658) *Observations upon Some Part of Sr Francis Bacon's Naturall History*, Oxford.

(1665) *A Treatise of Fruit-Trees*, 3rd ed., Oxford.

Avramov, Iordan, Hunter, Michael, and Yoshimoto, Hideyuki (2010) *Boyle's Books: The Evidence of his Citations*, Robert Boyle Project, Occasional Papers No 4.

Ayers, Michael (1991) *Locke: Epistemology and Ontology*, 2 vols., London: Routledge.

(1998) 'Theories of knowledge and belief', in Garber and Ayers 1998, 2, pp. 1003–61.

(2005) 'Was Berkeley an empiricist or a rationalist?', in *The Cambridge Companion to Berkeley*, ed. Kenneth P. Winkler, Cambridge: Cambridge University Press, pp. 34–62.

Bacon, Francis (1640) *Of the Advancement and Proficience of Learning*, Oxford.

(1676) *The Novum organum of Sir Francis Bacon, Baron of Verulam, Viscount St. Albans epitomiz'd, for a clearer Understanding of his Natural History*, London.

(1859) *The Works of Francis Bacon*, 7 vols., eds. J. Spedding, R. L. Ellis, and D. D. Heath, London: Longmans and Co.

(2000) *The Advancement of Learning, Oxford Francis Bacon*, vol. 4, ed. Michael Kiernan, Oxford: Clarendon Press.

(2004) *The* Instauratio magna *Part II*: Novum organum *and Associated Texts, Oxford Francis Bacon*, vol. 11, ed. Graham Rees, Oxford: Clarendon Press.

(2007) *Natural and Experimental History, Oxford Francis Bacon*, vol. 12, ed. Graham Rees, Oxford: Clarendon Press.

Baglivi, Giorgio (1696) *De praxi medica*, Rome.
(1704) *The Practice of Physick*, London.
Bampfield, Francis (1677a) *All in One. All useful sciences and profitable arts in one book of Jehovah Aelohim*, London.
(1677b) *Septima dies, dies desiderabilis, sabbatum Jehovae*, London.
Barbeyrac, Jean (1729) *An Historical Account of the Science of Morality*, London.
Barbieri, Lodovico (1752) *Nuovo saggio di metafisica, e di fisica generale. Parte prima*, Vicenza: Berno.
Barfoot, Michael (1990) 'Hume and the culture of science in the early eighteenth century', in M. A. Stewart 1990, pp. 151–90.
Barnes, Jonathan (2000) *Aristotle: A Very Short Introduction*, London: Routledge.
Barnouw, Jeffrey (1979) 'The philosophical achievement and historical significance of Johann Nicolas Tetens', *Studies in Eighteenth-Century Culture*, 9, pp. 301–35.
Barrow, Isaac (1734) *The Usefulness of Mathematical Learning*, London. 1st Latin ed. 1683.
Bartoli, Daniello (1677) *De' simboli trasportati al morale*, Venice: Hertz.
(1980 [1677]). Da 'La tensione e la pressione disputanti qual di loro sostenga l'argento vivo ne' cannelli dopo fattone il vuoto'", in Altieri Biagi and Basile 1980, pp. 1191–1201.
Batteux, Charles (2015) *The Fine Arts Reduced to a Single Principle*, trans. James O. Young, Oxford: Oxford University Press.
Baumgarten, Alexander Gottlieb (1750) *Aesthetica*, Frankfurt a.O.: Kleyb, repr. 1970.
Baxter, Richard (1654) *The Saints' Everlasting* Rest, London.
(1667) *The Reasons of the Christian Religion*, London.
(1675) *Catholick Theologie: Plain, Pure, Peaceable: for Pacification of the Dogmatical Word-Warriours*, London.
Beattie, James (1770) *An Essay on the Nature and Immutability of Truth in Opposition to Sophistry and Scepticism*, Edinburgh.
(1790) *Elements of Moral Science*, 2 vols., Edinburgh.
Beaumont, John (1685) *A Draught of a Design for the Writing of the History of Nature and Arts of the County of Somerset*, Oxford. Reprinted in Gunter 1923–45, vol. 12, pp. 275–8.
Bell, Matthew (2005) *The German Tradition of Psychology in Literature and Thought, 1700–1840*, Cambridge: Cambridge University Press.
Bennett, Jim (2013) 'The lost cabinet of experimental philosophy of the University of Oxford', in Bennett and Talas 2013, pp. 69–78.
Bennett, Jim and Talas, Sofia, eds. (2013) *Cabinets of Experimental Philosophy in Eighteenth-Century Europe*, Leiden: Brill.
Bennett, Jonathan (1971) *Locke, Berkeley, Hume: Central Themes*, Oxford: Clarendon Press.
(2001) *Learning from Six Philosophers: Descartes, Spinoza, Leibniz, Locke, Berkeley, Hume*, vol. 2, Oxford: Oxford University Press.
Bentham, Edward (1745) *An Introduction to Moral Philosophy*, 2nd ed., Oxford.

Bentley, Richard (1693) *The Folly and Unreasonableness of Atheism*, London.
Bernard, Jean-François (1715–27) *Receuil des voyages au nord*, 8 vols., Amsterdam.
Biener, Zvi and Schliesser, Eric (2014) 'Introduction', in *Newton and Empiricism*, eds. Zvi Biener and Eric Schliesser, Oxford: Oxford University Press, pp. 1–11.
Bilfinger, Georg Bernhard (1725) *Dilucidationes philosophicae de Deo, anima humana, mundo, et generalibus rerum affectionibus*, Tübingen: Cotta, repr. in Wolff 1962–, sect. 3, vol. 18.
Birch, Thomas (1756–7) *The History of the Royal Society of London*, 4 vols., London.
Bissinger, Anton (1970) *Die Struktur der Gotteserkenntnis: Studien zur Philosophie Christian Wolffs*, Bonn: Bouvier.
Blackmore, Sir Richard (1697) *King Arthur*, London.
Blair, Ann M. (2007) 'Organizations of knowledge', in *The Cambridge Companion to Renaissance Philosophy*, ed. James Hankins, Cambridge: Cambridge University Press, pp. 287–303.
Blakiston, Herbert E. D. (1898) *Trinity College*, London: F. E. Robinson.
Blanchet, Léon (1920) *Campanella*, Paris: Alcan.
Blome, Richard (1686) *The Gentlemans Recreation*, London.
Blount, Sir Thomas Pope (1693) *A Natural History Containing Many not Common Observations Extracted out of the best Modern Writers*, London.
Blundeville, Thomas (1617) *The Arte of Logike*, 2nd ed., London.
Boate, Gerard (1657) *Irelands Naturall History*, London.
Bodenmann, Siegfried and Rey, Anne-Lise, eds. (2018a) *What Does it Mean to be an Empiricist? Empiricisms in Eighteenth Century Sciences*, Cham: Springer.
Bodenmann, Siegfried and Rey, Anne-Lise (2018b) 'Introduction', in Bodenmann and Rey 2018a, pp. 1–11.
Böhr, Christoph (2003) *Philosophie für die Welt: Die Popularphilosophie der deutschen Spätaufklärung im Zeitalter Kants*, Stuttgart: Frommann-Holzboog.
Bohun, Ralph (1671) *A Discourse Concerning the Origine and Properties of Wind*, Oxford.
Bolnest, Edward (1665) *Medicina Instaurata, or A Brief Account of the True Grounds and Principles of the Art of Physick*, London.
Bondeli, Martin and Lazzari, Alessandro, eds. (2004) *Philosophie ohne Beynamen: System, Freiheit und Geschichte im Denken Karl Leonhard Reinholds*, Basel: Schwabe.
Born, Friedrich Gottlob (1791) *Versuch über die ursprünglichen Grundlagen des menschlichen Denkens und die davon abhängigen Schranken unserer Erkenntniß*, Leipzig: Barth, repr. 1969.
Boullier, David Renaud (1753) *Apologie de la métaphysique*, Amsterdam.
Bowen, Margarita (1981) *Empiricism and Geographical Thought: From Francis Bacon to Alexander von Humboldt*, Cambridge: Cambridge University Press.
Boyle, Robert (1661) *Some Motives and Incentives to the Love of God*, 2nd ed., London.

(1679) *Expériences curieuses de l'illustre Mr. Boyle, sur les saveurs et sur les odeurs*, in *Recueil d'Expériences . . . sur le combat, qui procède du mélange des corps*, trans. L. Le Vasseur, Paris, pp. 125–220.
(1692) *General Heads for the Natural History of a Country Great or Small Drawn out for the Use of Travellers and Navigators*, London.
(1725) *The Philosophical Works of the Honourable Robert Boyle, Esq*, 3 vols., ed. Peter Shaw, London.
(1991) *Selected Philosophical Papers of Robert Boyle*, ed. M. A. Stewart, Indianapolis: Hackett.
(1999–2000) *The Works of Robert Boyle*, eds. Michael Hunter and Edward B. Davis, 14 vols., London: Pickering and Chatto.
(2001) *The Correspondence of Robert Boyle*, 6 vols., eds. Michael Hunter, Antonio Clericuzio, and Lawrence M. Principe, London: Pickering and Chatto.
(2008 [1666]) *The Text of Robert Boyle's 'Designe about Natural History'*, ed. Michael Hunter and Peter R. Anstey, Robert Boyle Occasional Papers, 3, https://www.bbk.ac.uk/boyle/resources/occasional-papers.
Bracken, Harry M. (1974) *Berkeley*, New York: St. Martin's Press.
Bradley, James (1748) 'A letter to the Right Honourable George Earl of Macclesfield concerning an Apparent motion observed in some of the fixed stars', *Philosophical Transactions*, 45, pp. 1–43.
(1832) *Miscellaneous Works and Correspondence*, Oxford: Oxford University Press.
Brastberger, Gebhard Ulrich (1792) *Untersuchungen über Kants Kritik der practischen Vernunft*, Tübingen: Cotta, repr. 1971.
Braun, Lucien (1990) *Geschichte der Philosophiegeschichte*, trans. Ulrich Johannes Schneider, Darmstadt: Wissenschaftliche Buchgesellschaft.
Breazeale, Daniel (1998) 'Putting doubt in its place: Karl Leonhard Reinhold on the relationship between skepticism and transcendental idealism', in *The Skeptical Tradition around 1800: Skepticism in Philosophy, Science, and Society*, eds. Johan van der Zande and Richard H. Popkin, Dordrecht: Kluwer, pp. 119–32.
(2010) 'Reason's changing needs: from Kant to Reinhold', in *Karl Leonhard Reinhold and the Enlightenment*, ed. George di Giovanni, Dordrecht: Springer, pp. 89–111.
Breyer, Johann Friedrich (1791) *Ein Wort zur Ehrenrettung des Grundsazes der eigenen Vollkommenheit als ersten moralischen Gesezes*, Erlangen: Hilpert.
Brown, Robert (1828) 'A brief account of microscopical observations made in the months of June, July and August 1827, on the particles contained in the pollen of plants; and on the general existence of active molecules in organic and inorganic bodies', *The Philosophical Magazine*, 4 (21), pp. 161–73.
Brown, Stuart (1985) 'Leibniz's break with Cartesian rationalism', in *Philosophy, Its History and Historiography*, ed. A. J. Holland, Dordrecht: Reidel, pp. 195–208.

Brown, Stuart, ed. (1996a) *Routledge History of Philosophy*, vol. 5: *British Philosophy and the Age of Enlightenment*, London: Routledge.

Brown, Stuart (1996b) 'Introduction', in S. Brown 1996a, pp. 1–15.

Browne, John (1697) *Proposals by Way of Contribution for Writing a Natural History of Yorkshire*, London.

Brucker, Jakob (1766–7) *Historia critica philosophiae a mundi incunabulis ad nostram usque aetatem deducta*, 2nd enlarged ed., 6 vols., Leipzig: Breitkopf, repr. 1975.

Buckle, Stephen (1999) 'British Sceptical Realism: a fresh look at the British tradition', *European Journal of Philosophy*, 7, pp. 1–29.

Buffon, Georges-Louis Leclerc, comte de (1749–89) *Histoire naturelle, générale et particuliére*, 36 vols., Paris.

Buhle, Johann Gottlieb (1796–1804) *Lehrbuch der Geschichte der Philosophie und einer kritischen Literatur derselben*, 9 vols., Göttingen: Vandenhoeck und Ruprecht.

(1800–5) *Geschichte der neuern Philosophie seit der Epoche der Wiederherstellung der Wissenschaften*, 6 vols., Göttingen: Mittwe; later: Röwe, repr. 1969.

Bunge, Wiep van (2011) 'Spinoza and the idea of a scientific moral philosophy', in *Spinoza's Ethics: A Collective Commentary*, eds. Michael Hampe, Ursula Renz, and Robert Schnepf, Leiden: Brill, pp. 307–23.

Burgersdijck, Franco (1631) *Idea philosophiae tum naturalis, tum moralis*, 3rd revised ed., Oxford: Curteyne.

Burnet, Thomas (1681) *Telluris theoria sacra*, London.

Butler, Joseph (1736) *The Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature*, London.

Büsch, Johann Georg (1783) 'Ueber Französische und Deutsche Philosophie', *Deutsches Museum*, 1, pp. 209–28.

Cabeo, Niccolò (1646) *In quatuor libros meteorologicorum Aristotelis commentaria, et quaestiones quatuor tomis compræhensa, quibus non solum meteorologica, tum ex antiquorum dictis, tum maxime ex singularum rerum experimentis explicantur sed etiam vniuersa fere experimentalis philosophia exponitur*, Rome: Corbelletti.

(1686) *Philosophia experimentalis: Sive in* III. *Librum meterologicorum Aristotelis commentaria, et quaestiones*, Rome: Dondini.

Calvin, John (1890 [1559]) *Praelectiones in duodecim prophetas minores, in Opera quae supersunt omnia*, ed. E. Baum, in *Corpus Reformatorum*, vols. 43–4, Braunschweig: Schwetschke.

Camden, William (1586) *Britannia sive Florentissimorum regnorum, Angliae, Scotiae, Hiberniae, et insularum adiacentium ex intima antiquitate chorographica descriptio*, London.

Campanella, Tommaso (1620) *De sensu rerum et magia, libri quatuor* Frankfurt a.M.

(1622) *Apologia pro Galileo, mathematico florentino: Ubi disquisitur, utrum ratio philosophandi, quam Galileus celebrat, faveat sacris scripturis, an adversetur*, Frankfurt a.M.: Tampachius.

(1994) *Apologia pro Galileo/A Defense of Galileo*, ed. R. J. Blackwell, Notre Dame: University of Notre Dame Press.

Campo, Mariano (1939) *Cristiano Wolff e il razionalismo precritico*, Milan: Vita e Pensiero, vol. 1, repr. in Wolff 1962–, sect. 3, vol. 9.

Carboncini, Sonia (1987) 'L'*Encyclopédie* et Christian Wolff: A propos de quelques articles anonymes', *Les études philosophiques*, 4, pp. 489–504.

Carboncini, Sonia and Cataldi Madonna, Luigi, eds. (1992) *Nuovi studi sul pensiero di Christian Wolff* = Wolff 1962–, sect. 3, vol. 31, Hildesheim: Olms.

Carboncini-Gavanelli, Sonia (2007), 'Das Paradox der Aufklärung: Christian Wolff und die *Encyclopédie*', in *Christian Wolff und die europäische Aufklärung: Akten des 1. Internationalen Christian-Wolff-Kongresses*, 5 vols., eds. Jürgen Stolzenberg and Oliver-Pierre Rudolph, Hildesheim: Olms, 2007–9, vol. 1, pp. 73–94.

Carpenter, Audrey T. (2011) *John Theophilus Desaguliers: A Natural Philosopher, Engineer and Freemason in Newtonian England*, London: Continuum.

Carruthers, Peter (1992) *Human Knowledge and Human Nature: A New Introduction to an Ancient Debate*, New York: Oxford University Press.

Carus, Friedrich August (1809) *Nachgelassene Werke*, vol. 4: *Ideen zur Geschichte der Philosophie*, Leipzig: Barth and Kummer.

Casaubon, Meric (1669) *A Letter of Meric Casaubon D. D. &c. to Peter du Moulin D. D. Concerning Natural Experimental Philosophie*, Cambridge.

Cataldi Madonna, Luigi (1984) 'La metodologia empirica di Christian Wolff', *Il Cannocchiale*, pp. 59–93, repr. in Cataldi Madonna 2001b, pp. 12–46.

(1987) 'Wahrscheinlichkeit und wahrscheinliches Wissen in der Philosophie von Christian Wolff', *Studia leibnitiana*, 19, pp. 2–40.

(2001a) *Christian Wolff und das System des klassischen Rationalismus: Die philosophia experimentalis universalis* = Wolff 1962–, sect. 3, vol. 62, Hildesheim: Olms.

(2001b) 'Vernunft und Erfahrung: Zur Entwicklung der empirischen Methodologie in der Rationalistischen Tradition des 17. und 18. Jahrhunderts', in Cataldi Madonna 2001a, pp. 47–82.

Cavendish, Margaret (Duchess of Newcastle) (1664) *Philosophical Letters: or Modest Reflections Upon some Opinions in Natural Philosophy*, London.

(2001 [1666/8]) *Observations upon Experimental Philosophy*, ed. Eileen O'Neill, Cambridge: Cambridge University Press.

Caygill, Howard (1995) *A Kant Dictionary*, Malden, MA: Blackwell.

Chalmers, Alan (2012) 'Intermediate causes and explanations: the key to understanding the scientific revolution', *Studies in History and Philosophy of Science*, 43, pp. 551–62.

(2017) *One Hundred Years of Pressure: Hydrostatics from Stevin to Newton*, Cham: Springer.

Chambers, Ephraim (1728) *Cyclopaedia*, London.

Charleton, Walter (1669) *Two Discourses*, London.

(1674) *Natural History of the Passions*, London.

Cheyne, George (1705) *Philosophical Principles of Natural Religion*, London.
Childrey, Joshua (1660) *Britannia Baconica: Or, The Natural Rarities of England, Scotland, & Wales*, London.
Clarke, Desmond M. (1982) *Descartes' Philosophy of Science*, Manchester: Manchester University Press.
Clarke, Samuel (1705) *A Demonstration of the Being and Attributes of God, More Particularly in Answer to Mr Hobbs, Spinoza, And Their Followers*, London.
(1706) *A Discourse Concerning the Unchangeable Obligations of Natural Religion, and the Truth and Certainty of the Christian Revelation*, London.
(1711) *A Discourse Concerning the Being and Attributes of God, The Obligations of Natural Religion, and the Truth and Certainty of the Christian Revelation*, London.
(1717) *A Collection of Papers which passed between the late Learned Mr. Leibnitz and Dr. Clarke*, London.
Clarke, William (1670) *The Natural History of Nitre*, London.
Clerke, Gilbert (1662) *Tractatus de restitutione corporum*, London.
Clucas, Stephen (2010) '*Scientia* and *Inductio Scientifica* in the *Logica Hamburgensis* of Joachim Junjius', in Scientia *in Early Modern Philosophy: Seventeenth-Century Thinkers on Demonstrative Knowledge from First Principles*, eds. Tom Sorell, G. A. J. Rogers, and Jill Kraye, Dordrecht: Springer, pp. 53–70.
Clulee, Nicholas H. (1984) 'At the crossroads of magic and science: John Dee's Archemastrie', in *Occult and Scientific Mentalities in the Renaissance*, ed. Brian Vickers, Cambridge: Cambridge University Press, 57–71.
Cohen, I. Bernard (1966) 'Hypotheses in Newton's philosophy', *Physis*, 8, pp. 163–84.
(1971) *Introduction to Newton's* Principia, Cambridge, MA: Harvard University Press.
Cohen, I. Bernard and Smith, George E., eds. (2002) *The Cambridge Companion to Newton*, Cambridge: Cambridge University Press.
Colbatch, John (1696) *A Physico Medical Essay Concerning Alkaly and Acid*, London.
Coley, Noel G. (1979) '"Cures without care" "chymical physicians" and mineral waters in seventeenth-century English medicine', *Medical History*, 23, pp. 191–214.
Condillac, Etienne Bonnot de (1746) *Essai sur l'origine des connaissances humaines*, Paris.
(1749) *Traité des systèmes*, Paris.
(1982) *Philosophical Writings of Etienne Bonnot, Abbé de Condillac*, trans. Franklin Philip, Hillsdale: Lawrence Erlbaum.
Condorcet, Marquis de (1847) *Oeuvres de Condorcet*, vol. 2, Paris: Firmin Didot.
Conimbricenses (1616) *Commentariorum Collegii Conimbricensis Societatis Iesu, in octo libros physicorum Aristotelis Stagiritæ, Prima Pars*, Cologne: Zetzner.
Conrad, Elfriede (1994) *Kants Logikvorlesungen als neuer Schlüssel zur Architektonik der Kritik der reinen Vernunft: Die Ausarbeitung der*

Gliederungsentwürfe in den Logikvorlesungen als Auseinandersetzung mit der Tradition, Stuttgart: Frommann-Holzboog.

Conti, Antonio (1832), 'Prospetto di ogni filosofia', in *Opuscoli filologici dell'abate Antonio Conti padovano*, ed. Bartolomeo Gamba, Venice: Alvisopoli, pp. 73–96.

Cook, Harold J. (1986) *The Decline of the Old Medical Regime in Stuart London*, Ithaca: Cornell University Press.

(1989) 'Physicians and the new philosophy: Henry Stubbe and the virtuosi-physicians', in *The Medical Revolution of the Seventeenth Century*, eds. Roger French and Andrew Wear, Cambridge: Cambridge University Press, pp. 246–71.

(1990) 'The new philosophy and medicine in seventeenth-century England', in Lindberg and Westman 1990, pp. 397–436.

Copenhaver, Brian P. (1988) 'Astrology and magic', in Schmitt, Skinner, and Kessler 1988, pp. 264–300.

(1998) 'The occultist tradition and its critics', in Garber and Ayers 1998, 1, pp. 454–512.

Copenhaver, Rebecca (2013), 'Recent anthologies on modern philosophy', *Teaching Philosophy*, 36, pp. 161–72.

Copernicus, Nicolaus (1543) *De revolutionibus orbium coelestium*, Nuremberg.

Copleston, Frederick (1958) *A History of Philosophy*, vol. 4: *Descartes to Leibniz*, London: Burns and Oates & Washbourne.

(1959) *A History of Philosophy*, vol. 5: *Hobbes to Hume*, London: Burns and Oates & Washbourne.

(1960) *A History of Philosophy*, vol. 6: *Wolff to Kant*, London: Burns and Oates & Washbourne.

Cormack, Lesley B. (1991) '"Good fences make good neighbors": geography as self-definition in early modern England', *Isis*, 84, pp. 639–61.

Corr, Charles A. (1970) 'Certitude and utility in the philosophy of Christian Wolff', *Southwestern Journal of Philosophy*, 1, pp. 133–42.

(1975) 'Christian Wolff and Leibniz', *Journal of the History of Ideas*, 36, pp. 241–62.

Cotes, Roger (1738) *Hydrostatical and Pneumatical Lectures*, London.

Cowley, Abraham (1661) *A Proposition for the Advancement of Experimental Philosophy,* London.

Coxe, Daniel (1669) *A Discourse, wherein the Interest of the Patient in reference to Physick and Physicians is soberly debated*, London.

Crane, Edric (1976) 'Jean d'Alembert between Descartes and Newton: a critique of Thomas L. Hankins' position', *Isis*, 67, pp. 274–6.

Crivelli, Giovanni (1744), *Elementi di fisica*, 2nd ed., revised and enlarged, Venice.

Crombie, A. C. (1953) *Robert Grosseteste and the Origins of Experimental Science, 1100–1700*, Oxford: Clarendon Press.

Crusius, Christian August (1745) *Entwurf der nothwendigen Vernunft-Wahrheiten, wiefern sie den zufälligen entgegen gesetzet werden*, Leipzig: Gleditsch, repr. 1964.

Cumberland, Richard (1672) *De legibus naturae*, London.

(2005) [1672] *A Treatise of the Laws of Nature*, trans. John Maxwell, Indianapolis: Liberty Fund. 1st ed. 1727.

Cuneo, Terrence and van Woudenberg, René (2004) 'Introduction', in *The Cambridge Companion to Thomas Reid*, eds. Terrence Cuneo and René van Woudenberg, Cambridge: Cambridge University Press, pp. 1–30.

Currie, Adrian and Walsh, Kirsten (2019) 'Frameworks for historians and philosophers', *HOPOS*, 9, pp. 1–34.

Cushman, Herbert Ernest (1911) *A Beginner's History of Philosophy*, vol. 2: *Modern Philosophy*, Boston: Houghton Mifflin.

Daniel, Stephen H. (2007) 'The harmony of the Leibniz–Berkeley juxtaposition', in Phemister and Brown 2007, pp. 163–80.

D'Argens, Marquis (1737) *La philosophie du bon-sens, ou réfléxions philosophiques sur l'incertitude des connoissances humaines*, Amsterdam.

Daston, Lorraine (2011) 'The empire of observation, 1500–1800', in Daston and Lunbeck 2011, pp. 81–113.

Daston, Lorraine and Lunbeck, Elizabeth, eds. (2011) *Histories of Scientific Observation*, Chicago: University of Chicago Press.

Dawes, Greg (2016) 'Experiment, speculation, and Galileo's scientific reasoning', *Perspectives on Science*, 24, pp. 343–60.

Dear, Peter (1988) *Mersenne and the Learning of the Schools*, Ithaca: Cornell University Press.

(1995) *Discipline and Experience: The Mathematical Way in the Scientific Revolution*, Chicago: University of Chicago Press.

(2006) 'The meanings of experience', in Park and Daston 2006, pp. 106–31.

(2008) 'Cabeo, Niccolò', in *New Dictionary of Scientific Biography*, ed. Noretta Koertge, 26 vols., Detroit: Scribner's Sons, 2, pp. 1–3.

Dee, John (1570) 'Mathematicall præface', in *The Elements of Geometrie of the most Auncient Philosopher Euclide of Megara. Whereunto are Annexed Certaine Scholies, Annotations, and Inuentions, of the Best Mathematiciens, both of Time Past, and in this our Age*, trans. H. Billingsley, London: Daye, sigs. ☞.iij.–Aiiiiv.

Degérando, Joseph-Marie (1804) *Histoire comparée des systèmes de philosophie, relativement aux principes des connaissances humaines*, 3 vols., Paris: Henrichs.

Della Porta, Giambattista (1589) *Magiae naturalis libri xx*, 2nd enlarged ed., Naples.

(1658) *Natural Magick*, London.

Denstonius, Arnoldus Bachimius (1682) *Pan-sophia enchiretica seu Philosophia Universalis Experimentalis*, Nuremberg.

Dent, Arthur (1606) *A Pastime for Parents ... contayning the most Principall Grounds of Christian Religion*, 2nd ed., London.

Denyse, Jean (1719) *La nature expliquée par le raisonnement et par l'expérience*, Paris.

Derham, William (1715) *Astro-Theology: or a Demonstration of the Being and Attributes of God, from a Survey of the Heavens*, London.

Desaguliers, John Theophilus (1713) *A Catalogue of the Experiments in Mr Desaguliers's Course*, London.
(1719) *Lectures of Experimental Philosophy*, London.
(1734) *A Course of Experimental Philosophy,* vol. 1, London.
Descartes, René (1644) *Principia philosophiae*, Amsterdam.
(1996) *Oeuvres complètes de Descartes*, eds. Charles Adam and Paul Tannery, 11 vols., new ed., Paris: Vrin.
Des Chene, Dennis (2006) 'From natural philosophy to natural science', in *The Cambridge Companion to Early Modern Philosophy*, ed. Donald Rutherford, Cambridge: Cambridge University Press, pp. 67–94.
Desfontaines, Pierre-François Guyot and Granet, François (1739) *Observations sur les écrits modernes, tome dix-septième*, Paris.
Deslandes, André François (1736) *Recueil de différens traitez de physique et d'histoires naturelles*, Paris.
(1744) *Avertissement, ou discours sur la manière le plus avantageuse de faire des experiences*, Paris.
(1748) *Recueil de différens traitez de physique et d'histoires naturelles*, 2nd ed., Paris.
(1750) *Recueil de différens traitez de physique et d'histoires naturelles*, vol. 2, Paris.
Detlefsen, Karen (2019) 'Du Châtelet and Descartes on the roles of hypothesis and metaphysics in natural philosophy', in *Feminist History of Philosophy: The Recovery and Evaluation of Women's Philosophical Thought*, eds. Eileen O'Neill and Marcy P. Lascano, Cham: Springer, pp. 97–127.
Deusing, Anton (1644) *Naturae theatrum universale*, Harderwijk.
(1661) *Disquisitio physico-mathematica, Gemina, De vacuo itemque De attractione*, Amsterdam.
Di Bella, Santi (2008) *La storia della filosofia nell'aetas kantiana: Teorie e discussioni. Con appendice di testi*, Naples: Liguori.
Di Capua, Leonardo (1681) *Parere: Divisato in otto ragionamenti, ne quali partitamente narrandosi l'origine, e 'l progresso della medicina, chiaramente l'incertezza della medesima si fa manifesta*, Naples.
Diderot, Denis (1750) *Prospectus de l'Encyclopédie*, Paris. Trans. in d'Alembert 1995, pp. 106–40.
(1754) *Pensées sur l'interprétation de la nature*, Amsterdam.
(1755) 'Encyclopédie', in *Encyclopédie*, vol. 5, eds. Denis Diderot and Jean Le Rond d'Alembert, Paris, 1751–72, pp. 635–38A.
(1875) *Plan d'une université pour le gouvernement de Russie*, in *Oeuvres complètes de Diderot*, 7 vols., ed. Jules Assézat, Paris: Garnier, 3, pp. 429–546.
(1937) *Diderot, Interpreter of Nature: Selected Writings*, trans. J. Stewart and J. Kemp, London: Lawrence and Wishart.
(1999) *Thoughts on the Interpretation of Nature and Other Philosophical Works*, Manchester: Clinamen Press.

Diderot, Denis and d'Alembert, Jean Le Rond, eds. (2021) *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers*, University of Chicago: ARTFL Encyclopédie Project (Spring 2021 ed.), eds. Robert Morrissey and Glenn Roe, http://encyclopedie.uchicago.edu/. First published Paris, 1751–72.

Dieckmann, Herbert (1977) 'Natural history from Bacon to Diderot: a few guide-posts', in *Essays on the Age of the Enlightenment in Honor of Ira O. Wade*, ed. J. Macary, Geneva: Librairie Droz, pp. 93–112.

Di Giovanni, George and Harris, H. S., eds. and trans. (1985) *Between Kant and Hegel: Texts in the Development of Post-Kantian Idealism*, Albany: State University of New York Press.

Diogenes Laertius (1964) *Vitae philosophorum*, ed. H. S. Long, Oxford: Clarendon Press.

Dobre, Mihnea (2019) 'Jacques Rohault and Cartesian experimentalism', in *The Oxford Handbook of Descartes and Cartesianism*, eds. Steven Nadler, Tad M. Schmaltz, and Delphine Antoine-Mahut, Oxford: Oxford University Press, pp. 338–401.

Dobre, Mihnea and Nyden, Tammy, eds. (2013a) *Cartesian Empiricisms*, Dordrecht: Springer.

(2013b) 'Introduction', in Dobre and Nyden 2013, pp. 1–21.

Dodart, Denis (1676) *Mémoires pour Servir à l'Histoire des Plantes*, Paris.

Donne, John (1611) *An Anatomy of the World*, London.

Drake, Stillman and Drabkin, I. E., eds. (1969) *Mechanics in Sixteenth-Century Italy: Selections from Tartaglia, Benedetti, Guido Ubaldo, & Galileo*, Madison: University of Wisconsin Press.

Du Châtelet, Emilie (1740) *Institutions de physique*, Paris.

Ducheyne, Steffen (2012) *The Main Business of Natural Philosophy: Isaac Newton's Natural-Philosophical Methodology*, Dordrecht: Springer.

Du Hamel, Jean-Baptiste (1670) *De corporum affectionibus . . . seu promotae per experimenta philosophiae specimen*, Paris.

(1672) *De mente humana . . . variis illustrata experimentis pertractantur*, Paris.

(1673) *De corpore animato . . . seu promotae per experimenta philosophiae specimen alterum*, Paris.

(1678) *Philosophia vetus et nova*, 4 vols., Paris.

(1701) *Regiae scientiarum academiae historia*, Paris.

Dunton, John (1692) *The Young-Students-Library*, London.

Dyck, Corey (2014) *Kant and Rational Psychology*, Oxford: Oxford University Press.

Eamon, William (1994) *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture*, Princeton: Princeton University Press.

Easton, Patricia (2013) 'Robert Desgarbets on the physics and metaphysics of blood transfusion', in Dobre and Nyden 2013a, pp. 185–202.

Eberhard, Johann August (1776) *Allgemeine Theorie des Denkens und Empfindens*, Berlin: Voß, repr. 1972.

(1788–9) 'Ueber das Gebiet des reinen Verstandes', *Philosophisches Magazin*, 1, pp. 263–89. Published anonymously.

(1789–90) 'Weitere Ausführung der Untersuchung über die Unterscheidung der Urtheile in analytische und synthetische: Insonderheit in Beziehung auf die Recension des 3ten und 4ten Stücks dieses Magazins in der Allg. Litt. Zeit. 1789. No. 174. 175. 176.', *Philosophisches Magazin*, 2, pp. 285–315.

(1792) 'Auszug aus der Abhandlung De la Realité et de l'Idéalité des objets de nos connoissances', *Philosophisches Archiv*, 1, pp. 81–125.

Eberstein, W. L. G. Freiherr von (1794–9) *Versuch einer Geschichte der Logik und Metaphysik bey den Deutschen von Leibnitz bis auf gegenwartige Zeit*, Halle.

École, Jean (1966) 'Des rapports de l'expérience et de la raison dans l'analyse de l'âme ou la Psychologia empirica de Christian Wolff', *Giornale di metafisica*, 21, pp. 589–617, repr. in Jean École (1985), *Introduction à l'opus metaphysicum de Christian Wolff*, Paris: Vrin, pp. 49–77.

(1978) 'La conception wolffienne de la philosophie d'après le "Discursus praeliminaris de philosophia in genere"', *Filosofia oggi*, 1, pp. 403–28.

(1979a) 'De la notion de philosophie expérimentale chez Wolff', *Études philosophiques*, pp. 397–406, repr. in Jean École (1988), *Etudes et documents photographiques sur Wolff*, Hildesheim: Olms (= Wolff 1962–, sect. 3, vol. 11), pp. 53–62.

(1979b) 'En quels sens peut-on dire que Wolff est rationaliste?', *Studia Leibnitiana*, 11, pp. 45–61.

Edwards, Jeffrey (2004) 'Response to Knud Haakonssen', in *Teaching New Histories of Philosophy: Proceedings of a Conference*, ed. J. B. Schneewind, Princeton: University Center for Human Values, Princeton University, pp. 123–30.

Edwards, Jonathan (1758) *The Great Christian Doctrine of Original Sin*, Boston.

Ehrenberg, Stefan (1998) 'Geschichtliche Darstellung der Philosophie des 17. Jahrhunderts', in *Grundriss der Geschichte der Philosophie*, begründet von Friedrich Ueberweg, ed. Jean-Pierre Schobinger, Basel: Schwabe, 1, pp. 305–18.

Engfer, Hans-Jürgen (1996) *Empirismus versus Rationalismus? Kritik eines philosophiegeschichtlichen Schemas*, Padeborn: Schöningh.

Eustachius a Sancto Paolo (1614) *Summa philosophiae quadripartita, de rebus dialecticis, moralibus, physicis, & metaphysicis*, 3rd ed., Paris.

Evelyn, John (1676) *A Philosophical Discourse of Earth Relating to the Culture and Improvement of it for Vegetation*, London.

Favaretti Camposampiero, Matteo (2016) 'Bodies of inference: Christian Wolff's epistemology of the life sciences and medicine', *Perspectives on Science*, 24, pp. 361–79.

Feder, Johann Georg Heinrich (1774) *Logik und Metaphysik*, 4th ed., Göttingen: Dieterich.

(1777) 'Review of Johann Nicolaus Tetens, *Philosophische Versuche*', *Göttingische Anzeigen von gelehrten Sachen* (Zugabe, n. 33, 1777), pp. 513–25. Published anonymously.

(1779–93) *Untersuchungen über den menschlichen Willen, dessen Naturtriebe, Verschiedenheiten, Verhältniß zur Tugend und Glückseligkeit und die Grundregeln, die menschlichen Gemüther zu erkennen und zu regieren*, Göttingen: Meyer, repr. 1968.

(1787) *Ueber Raum und Caussalität zur Prüfung der kantischen Philosophie*, Göttingen: Dieterich, repr. 1968; partial trans. *On Space and Causality: An Examination of the Kantian Philosophy*, in Sassen 2000b, pp. 106–26.

(1788) 'Review of Thomas Reid, *Essay on the Intellectual Powers of Man*', *Philosophische Bibliothek*, 1, pp. 43–62. Published anonymously.

(1789) 'Review of Carl Christian Erhard Schmid, *Critik der reinen Vernunft im Grundrisse* and *Wörterbuch zum leichtern Gebrauch der Kantischen Schriften*, 2nd ed.', *Philosophische Bibliothek*, 2, pp. 228–30.

(1803) *Précis historique et critique de la philosophie de Kant, et des effets qu'elle a produits en Allemagne*, Paris.

(1825) *Feders Leben, Natur und Grundsätze*, ed. Karl August Ludwig Feder, Leipzig: Schwickert.

Feijóo y Montenegro, Benito Jerónimo (1726–39) *El Teatro crítico universal, o Discursos varios en todo género de materias para desengaño de errores comunes*, 9 vols., Madrid: Mojados.

(1733), 'El gran Magisterio de la experiencia', in Feijóo y Montenegro 1726–39, 5, pp. 148–284; trans. as 'The Great and Masterly Authority of Experience', in Benito Jerónimo Feijóo y Montenegro, *Essays, or Discourses*, 4 vols., London, 1780, 4, pp. 260–328.

Feingold, Mordechai (2001) 'Mathematicians and naturalists: Sir Isaac Newton and the Royal Society' in *Isaac Newton's Natural Philosophy*, eds. Jed Z. Buchwald and I. Bernard Cohen, Cambridge, MA: MIT Press, pp. 77–102.

(2016) 'Experimental philosophy: invention and rebirth of a seventeenth-century concept', *Early Science and Medicine*, 21, pp. 1–28.

Ferguson, Adam (1769) *Institutes of Moral Philosophy*, Edinburgh.

Fischer, Kuno (1856) *Franz Baco von Verulam: Die Realphilosophie und ihr Zeitalter*, Leipzig: Brockhaus; trans. as *Francis Bacon of Verulam: Realistic Philosophy and Its Age*, trans. John Oxenford, London: Longman, Brown, Green, Longmans, & Roberts, 1857.

Fisher, Saul (2005) *Pierre Gassendi's Philosophy and Science: Atomism for Empiricists*, Leiden: Brill.

Flatt, Johann Friedrich (1789) *Briefe über den moralischen Erkenntnisgrund der Religion überhaupt, und besonders in Beziehung auf die Kantische Philosophie*, Tübingen.

Flögel, Carl Friedrich (1778) *Geschichte des menschlichen Verstandes*, 3rd ed., Frankfurt a.M.

Fontenelle, Bernard Le Bovier (1708) *Histoire du renouvellement de l'Académie Royale des Sciences*, Paris.

Formey, Jean Henri Samuel (1746) 'Préface', in *Histoire de L'Académie Royale des Sciences et des Belles Lettres de Berlin*, 1745, Berlin, sig.)(4^{r}–)()(2^{v}.

(1748) 'Réglement de l'Academie', *Histoire de L'Académie Royale des Sciences et Belles Lettres*, 1746, Berlin, pp. 3–9.

(1750) 'Histoire de l'Academie', *Histoire de L'Académie Royale des Sciences et Belles Lettres depuis son origine jusqu'à present*, 1748, Berlin, pp. 1–44.

Franckowiak, Rémi (2013) 'Du Clos and the mechanization of chemical philosophy', in Garber and Roux 2013, pp. 285–301.

Francks, Richard (2003) *Modern Philosophy: The Seventeenth and Eighteenth Centuries*, London: Routledge.

Frank, Robert, Jr (1980) *Harvey and the Oxford Physiologists*, Berkeley: University of California Press.

Franklin, Allan (1986) *The Neglect of Experiment*, Cambridge: Cambridge University Press.

Freedman, Joseph S. (1985) *Deutsche Schulphilosophie im Reformationszeitalter (1500–1650): Ein Handbuch für den Hochschulunterricht*, 2nd ed., revised and enlarged, Münster: MAKS Publikationen.

(1994) 'Classifications of philosophy, the sciences, and the arts in sixteenth- and seventeenth-century Europe', *Modern Schoolman*, 72, pp. 37–65.

Freind, John (1709) *Praelectiones chymicae*, London.

(1711) 'Praelectionum chymicarum vindiciae, in quibus Objectiones, in Actis Lipsiensibus Anno 1710', *Philosophical Transactions*, 27.331, pp. 330–42.

(1712) *Chymical Lectures*, London.

Gäbe, Lüder (1972) *Descartes' Selbstkritik: Untersuchungen zur Philosophie des jungen Descartes*, Hamburg: Meiner.

Garber, Daniel (2001) 'Descartes and experiment in the *Discourse* and *Essays*', in *Descartes Embodied*, Cambridge: Cambridge University Press, pp. 85–110.

(2022) 'Novatores', in *The Cambridge History of the Philosophy of the Scientific Revolution*, eds. David M. Miller and Dana Jalobeanu, Cambridge: Cambridge University Press, pp. 35–57.

Garber, Daniel and Ayers, Michael, eds. (1998) *The Cambridge History of Seventeenth-Century Philosophy*, 2 vols., Cambridge: Cambridge University Press.

Garber, Daniel and Roux, Sophie, eds. (2013) *The Mechanization of Natural Philosophy*, Dordrecht: Springer.

Garrett, Aaron and Heydt, Colin (2015) 'Moral philosophy: speculative and practical', in *Scottish Philosophy in the Eighteenth Century, Volume 1: Morals, Politics, Art, Religion*, eds. Aaron Garrett and James Harris, Oxford: Oxford University Press, pp. 77–130.

Garrett, Donald (1997) *Cognition and Commitment in Hume's Philosophy*, Oxford: Oxford University Press.

(2004) 'Philosophy and history in the history of modern philosophy', in *The Future for Philosophy*, ed. Brian Leiter, Oxford: Oxford University Press, pp. 44–73.

Garve, Christian (1796) 'Einige Beobachtungen über die Kunst zu denken', in *Versuche über verschiedene Gegenstände aus der Moral, der Litteratur und dem gesellschaftlichen Leben*, Breslau, 2, pp. 245–430.

Garve, Christian and Johann Georg Heinrich Feder (1782) 'Review of Immanuel Kant, *Kritik der reinen Vernunft*', *Göttingische Anzeigen von gelehrten Sachen*, 3, pp. 40–8; trans. in Immanuel Kant, *Prolegomena to Any Future Metaphysics That Will Be Able to Present Itself as Science*, ed. Günther Zoeller, Oxford: Oxford University Press, 2004, pp. 187–92.

Gassendi, Pierre (1658) *Exercitationes paradoxicae adversus Aristoteleos*, in *Opera omnia*, 3 vols., Lyon, 3, pp. 95–210.

Gaukroger, Stephen (1993) 'Descartes: methodology', in Parkinson 1993, pp. 156–86.

(2010) *The Collapse of Mechanism and the Rise of Sensibility: Science and the Shaping of Modernity, 1680–1760*, Oxford: Clarendon Press.

Gaukroger, Stephen, Schuster, John, and Sutton, John, eds. (2000) *Descartes' Natural Philosophy*, London: Routledge.

Gawlick, Günter and Kreimendahl, Lothar (1987) *Hume in der deutschen Aufklärung: Umrisse einer Rezeptionsgeschichte*, Stuttgart: Frommann-Holzboog.

Gentile, Marino (1966) *Se e come è possibile la storia della filosofia*, Padua: Liviana.

Georgescu, Laura and Giurgea, Mădălina (2012) 'Redefining the role of experiment in Bacon's natural history: how Baconian was Descartes before emerging from his cocoon?', *Early Science and Medicine*, 17, pp. 158–80.

Giglioni, G. (2010) 'Mastering the appetites of matter: Francis Bacon's *Sylva Sylvarum*', in Wolfe and Gal 2010a, pp. 149–67.

Gilbert, William (1600) *De magnete*, London.

Givone, Sergio (1972) *La storia della filosofia secondo Kant*, Milan: Mursia.

Glanvill, J. (1665) *Scepsis Scientifica*, London.

(1668) *Plus Ultra*, London.

(1671) *Philosophia Pia: or a Discourse of the Religious Temper, and Tendencies of the Experimental Philosophy*, London.

Glass, David J. (2014) *Experimental Design for Biologists*, 2nd ed., Cold Spring Harbor: Cold Spring Harbor Laboratory Press.

Glass, David J. and Hall, Ned (2008) 'A brief history of the hypothesis', *Cell*, August 8, pp. 378–81.

Glisson, Francis (1672) *Tractatus de natura substantiae energetica, seu de vita naturae*, London.

Gómez, Juan Manuel (2012a) 'The philosophy of George Turnbull', PhD thesis, University of Otago.

(2012b) 'Tracking terms in the *Encyclopedia Britannica*', *Early Modern Experimental Philosophy Blog*, 24 July 2012, https://bit.ly/3MrLePp.

(2020) 'Experimental philosophy in early modern Spain', in Jalobeanu and Wolfe 2020: https://bit.ly/3CjabIh

Gómez López, Susana (2002) 'Experiencia, historia, memoria: Acerca de una transformación en la Revolución Científica', *Revista de Filosofía*, 27, pp. 75–111.

Goubet, Jean-François (2002) 'Fondement, principes et utilité de la connaissance: Sur la notion wolffienne de système', *Archives de philosophie*, 65, pp. 81–103.

Grafton, Anthony (2005) *Magic and Technology in Early Modern Europe: Dibner Library Lecture. 15 October, 2002*, Washington, DC: Smithsonian Institution Libraries.

Graunt, John (1662) *Natural and Political Observations Mentioned in a Following Index, and Made Upon Bills of Mortality*, London.

Gravesande, Willem Jacob van 's (1720–1) *Physices elementa mathematica*, 2 vols., Leiden.

(1737) *Introductio ad philosophiam: Metaphysicam et logicam continens*, 2nd ed., Leiden, repr. in Wolff 1962–, sect. 3, vol. 67.

Greene, Robert (1707) *ΕΓΚΥΚΛΟΠΑΙΔΕΙΑ or A Method of Instructing Pupils*, n.p.

Gregor, Mary J. (1996) 'Editorial notes', in Immanuel Kant, *Practical Philosophy*, Cambridge: Cambridge University Press, pp. 628–40.

Grew, Nehemiah (1678) *Experiments in Consort of the Luctation Arising from the Affusion of Several Menstruums upon all Sorts of Bodies Exhibited to the Royal Society*, London.

(1679a) *Luctation*, trans. Guy Mesmin, Paris.

(1679b) *Expériences de Mr. Grew . . . sur le combat qui arrive du mélange de diverses liqueurs avec toutes sortes de corps*, in *Recueil d'Expériences . . . sur le combat, qui procède du mélange des corps*, trans. L. Le Vasseur, Paris, pp. 1–124.

Grier, Michelle (2001) *Kant's Doctrine of Transcendental Illusion*, Cambridge: Cambridge University Press.

Gröning, Johann (1701) *Historia cycloeidis*, Hamburg.

Grün, Johann (1587) *Philosophiae origo, progressus, definitio, divisio, dignitas, utilitas*, Wittenberg: Welack.

Gueroult, Martial (1968) *Spinoza*, vol. 1: *Dieu (Ethique, I)*, Paris: Aubier-Montaigne.

Guerrini, Anita (1985) 'James Keill, George Cheyne, and Newtonian physiology, 1690–1740', *Journal of the History of Biology*, 18, pp. 247–66.

(1996) 'Newtonianism, medicine and religion', in *Religion and Medicine in Seventeenth Century England*, eds. Ole Peter Grell and Andrew Cunningham, Aldershot: Ashgate, pp. 293–312.

(2000) *Obesity and Depression in the Enlightenment: The Life and Times of George Cheyne*, Norman: University of Oklahoma Press.

Guglielmini, Domenico (1688) *Riflessioni filosofiche dedotte dalle figure de' sali: Espresse in un discorso recitato nell'Accademia Filosofica*

Esperimentale di Monsign. Arcidiacono Marsigli la sera delli 21. Marzo 1688, Bologna.
Gunter, R. T. (1923–45) *Early Science in Oxford*, 14 vols., Oxford: Printed for the Subscribers.
Haakonssen, Knud, ed. (2006a) *The Cambridge History of Eighteenth-Century Philosophy*, 2 vols., Cambridge: Cambridge University Press.
Haakonssen, Knud (2006b) 'The history of eighteenth-century philosophy: history or philosophy?', in Haakonssen 2006a, 1, pp. 3–25.
Hackett, Jeremiah (1994) '*Scientia Experimentalis*: from Robert Grosseteste to Roger Bacon', in *Robert Grosseteste: New Perspectives On His Thought And Scholarship*, ed. James McEvoy, Dordrecht: Kluwer, pp. 89–119.
(2020) 'Roger Bacon', in *The Stanford Encyclopedia of Philosophy* (Summer 2020 ed.), ed. Edward N. Zalta, https://stanford.io/3fWY4sE.
Hacking, Ian (1983) *Representing and Intervening: Introductory Topics in the Philosophy of Science*, Cambridge: Cambridge University Press.
Hahn, Roger, (1971) *The Anatomy of a Scientific Institution: The Paris Academy of Sciences, 1666–1803*, Berkeley: University of California Press.
Hale, Matthew (1677) *The Primitive Origination of Mankind*, London.
Hales, Stephen (1735) *La statique des vegetaux, et l'analyse de l'air*, trans. Comte de Buffon, Paris.
Halley, Edmund (1687) 'An historical account of the trade winds, and monsoons', *Philosophical Transactions*, 16.183, pp. 153–68.
(1691) 'An account of the circulation of the watry vapours of the sea, and of the cause of springs', *Philosophical Transactions*, 16.192, pp. 468–73.
Hamann, Johann Georg (1824 [1781]) 'Recension der Critik der reinen Vernunft', in *Hamann's Schriften*, 8 vols., ed. Friedrich Roth, Berlin: Reimer, 6, pp. 45–54.
Hankins, Thomas L. (1970) *Jean d'Alembert: Science and the Enlightenment*, Oxford: Clarendon Press.
Hans, Nicholas (1951) *New Trends in Education in the Eighteenth Century*, London: Routledge & Kegan Paul.
Harris, John (1697) *Remarks on Some Late Papers, Relating to the Universal Deluge: And to the Natural History of the Earth*, London.
(1708) *Lexicon Technicum*, vol. 1, 2nd ed., London.
(1710) *Lexicon Technicum*, vol. 2, London.
(1719) *The History of Kent in Five Parts*, London.
Harrison, Peter (2011) 'Experimental religion and experimental science in early modern England', *Intellectual History Review*, 21, pp. 413–33.
Hartlib, Samuel (1652) *Cornu copia. A Miscellanium of Luciferous and most Fructiferous Experiments*, London.
Hartsoeker, Nicolaas (1710) *Eclaircissemens sur les conjectures physiques*, Amsterdam.
Harvey, Gideon (1663) *Archelogia Philosophica Nova, or New Principles of Philosophy*, London.

Hatfield, Gary (1990) *The Natural and the Normative: Theories of Spatial Perception from Kant to Helmholtz*, Cambridge, MA: MIT Press.

(2005) 'The history of philosophy as philosophy', in *Analytic Philosophy and History of Philosophy*, eds. Tom Sorell and G. A. J. Rogers, Oxford: Clarendon Press, pp. 83–128.

Hattab, Helen (2005) 'From mechanics to mechanism: the *Quaestiones Mechanicae* and Descartes' physics', in Anstey and Schuster 2005, pp. 99–129.

Hausius, Karl Gottlob (1793) *Materialien zur Geschichte der critischen Philosophie*, vol. 3: *Dritte Sammlung, praktischen Inhalts*, Leipzig, repr. 1969.

Heimsoeth, Heinz (1960a) *Atom, Seele, Monade: Historische Ursprünge und Hintergründe von Kants Antinomie der Teilung*, Mainz: Akademie der Wissenschaften und der Literatur.

(1960b) 'Zeitliche Weltunendlichkeit und das Problem des Anfangs: Eine Studie zur Vorgeschichte von Kants Erster Antinomie', in *Festschrift H. J. de Vleeschauwer*, Pretoria, pp. 22–45.

(1966–71) *Transzendentale Dialektik: Ein Kommentar zu Kants Kritik der reinen Vernunft*, vol. 4: *Die Methodenlehre*, Berlin: de Gruyter.

Heineccius, Johann Gottlieb (1733) *Elementa philosophiæ rationalis et moralis*, revised ed., Amsterdam.

Heinicke, Samuel (1788) *Wörterbuch zur Kritik der reinen Vernunft und zu den philosophischen Schriften von Herrn Kant*, Presburg, repr. 1968.

Heinz, Marion (2004) 'Untersuchungen zum Verhältnis von Geschichte und System der Philosophie in Reinholds Fundamentschrift', in Bondeli and Lazzari 2004, pp. 334–46.

Helvétius, Claude-Adrien (1758) *De l'esprit*, Paris.

(1777) *A Treatise on Man*, trans. W. Hooper, London.

Hemmens, Susan (2015) 'Crow's nest and beyond: chymistry in the Dublin Philosophical Society, 1683–1709', *Intellectual History Review*, 25, pp. 59–80.

Henrich, Dieter (1957–8) 'Hutcheson und Kant', *Kant-Studien*, 49, pp. 49–69.

Henry, John (2002) *The Scientific Revolution and the Origins of Modern Science*, 2nd ed., New York: Palgrave.

Herz, Markus (1990 [1771]) *Betrachtungen aus der spekulativen Weltweisheit*, ed. Elfriede Conrad, Heinrich P. Delfosse, and Birgit Nehren, Hamburg: Meiner.

Hettche, Matt (2016) 'Christian Wolff', in *The Stanford Encyclopedia of Philosophy* (Winter 2019 ed.), ed. Edward N. Zalta, https://stanford.io/3Mkj34Q.

Heumann, Christoph August (1716) *Acta philosophorum, Das ist: Gründl. Nachrichten aus der Historia Philosophica, Nebst beygefügten Urtheilen von denen dahin gehörigen alten und neuen Büchern*, vol. 5. Halle.

Heyd, Michael (1995) *'Be Sober and Reasonable': The Critique of Enthusiasm in the Seventeenth and Early Eighteenth Centuries*, Leiden: Brill.

Heydt, Colin (2013) 'Practical ethics', in *The Oxford Handbook of British Philosophy in the Eighteenth Century*, ed. James Harris, Oxford: Oxford University Press, pp. 369–89.

Hill, Ruth (2000) *Sceptres and Sciences in the Spains: Four Humanists and the New Philosophy (ca. 1680–1740)*, Liverpool: Liverpool University Press.

Hine, Ellen M. (1979) *A Critical Study of Condillac's* Traité des systèmes, The Hague: Martinus Nijhoff.

Hinske, Norbert (1975) 'Einleitung', in the reprint of Carl Christian Erhard Schmid, *Wörterbuch zum leichtern Gebrauch der Kantischen Schriften*, Darmstadt: Wissenschaftliche Buchgesellschaft, pp. vii–xxxii.

(1980) 'Reimarus zwischen Wolff und Kant: Zur Quellen- und Wirkungsgeschichte der Vernunftlehre von Hermann Samuel Reimarus', in *Logik im Zeitalter der Aufklärung: Studien zur 'Vernunftlehre' von Hermann Samuel Reimarus*, ed. Wolfgang Walter and Ludwig Borinski, Göttingen: Vandenhoeck und Ruprecht, pp. 9–32.

(1993) 'Georg Friedrich Meier und das Grundvorurteil der Erfahrungserkenntnis: Noch eine unbemerkt gebliebene Quelle der Kantschen Antinomienlehre', in *Kant und sein Jahrhundert: Gedenkschrift für Giorgio Tonelli*, ed. Claudio Cesa and Norbert Hinske, Frankfurt a.M.: Lang, pp. 103–21.

Hißmann, Michael (1777) *Psychologische Versuche: Ein Beytrag zur Esoterischen Logik*, Frankfurt a.M.

(1778) *Briefe über Gegenstände der Philosophie an Leserinnen und Leser*, Gotha.

Hobbes, Thomas (1845 [1661]) *Dialogus physicus*, in *Thomae Hobbes Malmesburiensis opera philosophica quae Latine scripsit omnia*, vol. 4, ed. William Molesworth, London: Bohn, pp. 233–96.

Hochstrasser, Tim J. (2000) *Natural Law Theories in the Early Enlightenment*, Cambridge: Cambridge University Press.

Hogarth, Alan J. and Witmore, Michael (2020) 'Reflexive witnessing: Boyle, the Royal Society and scientific style', *Notes and Records*, 74, pp. 131–48.

Hogelande, C. van (1646) *Cogitationes quibus Dei Existentia item Animae Spiritalitas, et possibilis cum corpore unio, demonstratur: nec non, brevis Historia Oeconomiae Corporis Animalis, proponitur, atque Mechanice explicatur*, Amsterdam.

Holst, Ludolf (1791) *Ueber das Fundament der gesammten Philosophie des Herrn Kant*, Halle, repr. 1968.

Holzhey, Helmut and Mudroch, Vilem (2005) *Historical Dictionary of Kant and Kantianism*, Lanham: Scarecrow Press.

Home, Henry (Lord Kames) (1774–5) *Sketches of the History of Man*, 4 vols., Dublin.

Home, R. W. (1985) 'The notion of experimental physics in early eighteenth-century France', in *Change and Progress in Modern Science*, ed. J. C. Pitt, Dordrecht: D. Reidel, pp. 107–31.

Hooke, Robert (1661) *An attempt for the Explication of the Phænomena*, London.

(1665) *Micrographia: Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses with Observations and Inquiries Thereupon*, London.

(1674) *An Attempt to Prove the Motion of the Earth*, London.

(1678) *Lectures and Collections*, London.
(1705a) *The Posthumous Works of Robert Hooke*, ed. Richard Waller, London.
(1705b) *A General Scheme, or Idea of the Present State of Natural Philosophy*, in Hooke 1705a, pp. 1–70.
(1705c) 'Lectures and discourses of earthquakes and subterraneous eruptions', in Hooke 1705a, pp. 279–450.
(1726) *Philosophical Experiments and Observations*, ed. William Derham, London.
(1757 [1672]) 'Considerations upon Mr. Newton's discourse on light and colours', in Birch 1756–7, vol. 3, pp. 10–15.
Hoppen, K. Theodore (1970) *The Common Scientist in the Seventeenth Century: A Study of the Dublin Philosophical Society 1683–1708*, London: Routledge & Kegan Paul.
(2008) *Papers of the Dublin Philosophical Society (1683–1709)*, 2 vols., ed. K. Theodore Hoppen, Dublin: Irish Manuscripts Collection.
Hoquet, Thierry (2005) *Buffon: histoire naturelle et philosophie*, Paris: Honoré Champion.
(2010) "History without time: Buffon's natural history as a nonmathematical physique", *Isis*, 101, pp. 30–61.
Huenemann, Charlie (2008) *Understanding Rationalism*, Stocksfield: Acumen.
Hume, David (1998) *An Enquiry Concerning the Principles of Morals*, ed. Tom Beauchamp, Oxford: Clarendon Press.
(2007a [1739–40]) *A Treatise of Human Nature*, vol. 1, eds. David F. Norton and Mary J. Norton, Oxford: Clarendon Press.
(2007b [1748]) *An Enquiry Concerning Human Understanding*, ed. Peter Millican, Oxford: Oxford University Press.
Hunter, Ian (2001) *Rival Enlightenments: Civil and Metaphysical Philosophy in Early Modern Germany*, Cambridge: Cambridge University Press.
(2007) 'The history of philosophy and the persona of the philosopher', *Modern Intellectual History*, 4, pp. 572–600.
Hunter, M. (1989a) *Establishing the New Science: The Experience of the Early Royal Society*, Woodbridge: Boydell.
(1989b) 'Latitudinarianism and the "ideology" of the early Royal Society: Thomas Sprat's *History of the Royal Society* (1667) reconsidered', in M. Hunter 1989a, pp 45–71.
(1989c) 'Science, technology and patronage: Robert Hooke and the Cutlerian Lectureship', in M. Hunter 1989a, pp. 279–338.
(1989d) 'An experiment in corporate enterprise: the Royal Society's committees of 1663–5, with a transcript of the surviving minutes of their meetings', in M. Hunter 1989a, pp. 73–121.
(1995) *Science and the Shape of Orthodoxy: Intellectual Change in Late Seventeenth-Century Britain*, Woodbridge: Boydell.
(2000) *Robert Boyle 1627–1691: Scrupulosity and Science*, Woodbridge: Boydell.

(2007a) *The Boyle Papers: Understanding the Manuscripts of Robert Boyle*, Aldershot: Ashgate.

(2007b) 'Robert Boyle and the early Royal Society: a reciprocal exchange in the making of Baconian science', *British Journal for the History of Science*, 40, pp. 1–23.

Hunter, Michael and Wood, Paul (1989) 'Towards Solomon's house: rival strategies for reforming the early Royal Society', in M. Hunter 1989a, pp. 185–244.

Hutcheson, Francis (1728) *An Essay on the Nature and Conduct of the Passions and Affections*, London.

(2004) *An Inquiry into the Original of our Ideas of Beauty and Virtue*, ed. Wolfgang Leidhold, Indianapolis: Liberty Fund.

Huygens, Christiaan (1888–1950) *Oeuvres complètes de Christiaan Huygens*, 22 vols., The Hague: Nijhoff.

Ishiguro, Hidé (1986) 'Pre-established harmony versus constant conjunction: a reconsideration of the distinction between Rationalism and Empiricism', in *Rationalism, Empiricism, and Idealism: British Academy Lectures on the History of Philosophy*, ed. Anthony Kenny, Oxford: Clarendon Press, pp. 61–85.

Jacobi, Friedrich Heinrich (1869) *Aus F. H. Jacobi's Nachlaß: Ungedruckte Briefe von und an Jacobi und andere; nebst ungedruckten Gedichten von Goethe und Lenz*, vol. 1, ed. Rudolf von Zoeppritz, Leipzig: Engelmann.

Jakob, Ludwig Heinrich (1788) *Grundriß der allgemeinen Logik und kritische Anfangsgründe der allgemeinen Metaphysik*, Halle: Francke und Bispink.

Jalobeanu, Dana (2015) *The Art of Experimental Natural History: Francis Bacon in Context*, Bucharest: Zeta Books.

Jalobeanu, Dana and Matei, Oana (2020) 'Treating plants as laboratories: a chemical natural history of vegetation in 17th-century England', *Centaurus*, 62, pp. 542–61.

Jalobeanu, Dana and Wolfe, Charles, eds. (2020) *Encyclopedia of Early Modern Philosophy and the Sciences*, https://bit.ly/3CV6dqV.

Janiak, Andrew (2015) *Newton*, Oxford: Wiley Blackwell.

Jardine, Lisa (1974) *Francis Bacon: Discovery and the Art of Discourse*, Cambridge: Cambridge University Press.

Johnson, Samuel (1746) Ethices elementa *or the First Principles of Moral Philosophy*, Boston.

Johnson, Dr Samuel (1768) *A Dictionary of the English Language*, 3rd revised ed., Dublin.

Johnston, John (1634) *Naturæ constantia*, Amsterdam.

(1657) *A History of the Constancy of Nature*, London.

Jorink, Eric and Mass, Ad, eds. (2012) *Newton and the Netherlands: How Isaac Newton Was Fashioned in the Dutch Republic*, Amsterdam: Leiden University Press.

Jorink, Erik and Zuidervaart, Huib (2012) '"The miracle of our time": how Isaac Newton was fashioned in the Netherlands', in Jorink and Mass 2012, pp. 13–65.

Jurin, James (1719) 'Remarks on a fragment of an old Roman inscription found in the north of England', *Philosophical Transactions*, 30.356, pp. 1717–19.

(1723) 'Invitatio ad observationes meteorologicas communi consilio instituendas', *Philosophical Transactions*, 32.379, pp. 422–7.

(1728) 'To Martin Folkes, Esq; Vice-President of the Royal Society', *Philosophical Transactions*, 34, sigs. A2^{r-v}.

Kant, Immanuel, (1900–) *Gesammelte Schriften*, ed. Königlich Preußische (Deutsche) Akademie der Wissenschaften, 29 vols., Berlin: Reimer, later: de Gruyter.

(1992–) *The Cambridge Edition of the Works of Immanuel Kant*, general editors Paul Guyer and Allen W. Wood, Cambridge: Cambridge University Press.

(1996) *Kritik der reinen Vernunft*, ed. Jens Timmermann, Hamburg: Meiner.

Kassler, Jamie C. (2014) *Seeking Truth: Roger North's Notes on Newton and Correspondence with Samuel Clarke c. 1704–1713*, Farnham: Ashgate.

Kate, Lambert Ten (1716) *Den schepper in Zyn bestier te kennen in Zyne schepselen; Volgens het Licht der Reden en Wiskonst. Tot Opbouw van Eerbiedigen Godsdienst en Vernietiging van alle Grondslag van Atheïstery, als mede tot een regtzinnig gebruyk van de philosophie*, Amsterdam.

Keckermann, Bartholomäus (1606) 'Positiones de philosophiæ natura & partibus, ex duobus praecognitorum philosophicorum Capitibus', in *Disputationes philosophicæ, physicæ praesertim*, Hanau, pp. 1–3.

Keill, James (1708) *An Account of Animal Secretion, The Quantity of Blood in the Humane Body and Muscular Motion*, London.

Keill, John (1698) *An Examination of Dr Burnet's Theory of the Earth*, Oxford.

(1702) *Introductio ad veram physicam*, Oxford.

(1708) 'Epistola ad Cl. virum Gulielmum Cockburn, Medicinea Doctorem. In qua Leges Attractiones aliaque Physices Principia traduntur', *Philosophical Transactions*, 26.315, pp. 97–110.

(1720) *An Introduction to Natural Philosophy: or, Philosophical Lectures Read in the University of Oxford, Anno Dom. 1700*, London.

(1809) 'On the laws of attraction and other physical principles. By Mr John Keill AM of Christ-church College, Oxford. No 315, p. 97. Translated from the Latin', in *The Philosophical Transactions of the Royal Society of London from their Commencement, in 1665, to the Year 1800, Abridged*, vol. 5, *from 1703 to 1712*, London: C. and R. Baldwin, pp. 417–24.

Kessler, Eckhard (2001) 'Metaphysics or empirical science? The two faces of Aristotelian natural philosophy in the sixteenth century', in Pade 2001, pp. 79–101.

Kessler, Eckhard, Lohr, Charles H., and Sparn, Walter, eds. (1988) *Aristotelismus und Renaissance*, Wiesbaden: Otto Harrassowitz.

Kircher, Athanasius (1641) *Magnes sive de arte magnetica opus tripartitum*, Rome: Grignani.

(1680) *Physiologia Kircheriana Experimentalis: Qua Summa Argumentorum Multitudine & Varietate Naturalium rerum scientia per experimenta Physica, Mathematica, Medica, Chymica, Musica, Magnetica, Mechanica comprobatur atque stabilitur*, ed. Johann S. Koestler, Amsterdam: Janssonio-Waesbergius.

Klein, Alexander Mugar (2007) 'The Rise of Empiricism: William James, Thomas Hill Green, and the Struggle over Psychology', PhD thesis, Bloomington: Indiana University, https://bit.ly/3V8PCqq.

Klosko, George (1980) 'Montesquieu's science of politics: absolute values and ethical relativism', in *L'Esprit des lois, Studies on Voltaire and the Eighteenth Century*, 189, pp. 153–77.

Knight, Harriet and Hunter, Michael (2007) 'Robert Boyle's *Memoirs for the Natural History of Human Blood* (1684): print, manuscript and the impact of Baconianism in seventeenth-century medical science', *Medical History*, 51, pp. 145–64.

Knutzen, Martin (1747) *Elementa philosophiae rationalis seu logicae*, Königsberg: Hartung, repr. 1991.

Koinm, Albert J. (2000) 'Christopher Merret's use of experiment', *Notes and Records of the Royal Society*, 54, pp. 23–32.

Kolmer, Petra (1998) *Philosophiegeschichte als philosophisches Problem: Kritische Überlengungen namentlich zu Kant und Hegel*, Freiburg: Alber.

Kraye, Jill (2010) 'Pietro Pomponazzi (1462–1525): secular Aristotelianism in the Renaissance', in *Philosophers of the Renaissance*, ed. P. Richard Blum, Washington, DC: Catholic University of America Press, pp. 92–115.

Kreimendahl, Lothar (1998) 'Review of Hans-Jürgen Engfer, *Empirismus versus Rationalismus?*', *Philosophische Rundschau*, 45, pp. 268–75.

Krug, Wilhelm Traugott (1827) *Fundamentalphilosophie oder urwissenschaftliche Grundlehre, als erster Haupttheil eines vollständigen Systems der Philosophie*, 3rd ed., revised and enlarged, Leipzig: Voss.

Krüger, Johann Gottlob (1756) *Versuch einer Experimental-Seelenlehre*, Halle.

Kuehn, Manfred (1987a) 'Hume in the Göttingische Anzeigen: 1739–1800', *Hume Studies*, 13, pp. 46–73.

(1987b) *Scottish Common Sense in Germany, 1768–1800: A Contribution to the History of Critical Philosophy*, Kingston and Montreal: McGill-Queen's University Press.

(1989) 'Hume and Tetens', *Hume Studies*, 15, pp. 365–76.

(1995) 'Mendelssohn's critique of Hume', *Hume Studies*, 21, pp. 197–220.

(1996) 'The German Aufklärung and British philosophy', in Brown 1996a, pp. 253–72.

(2005) 'The reception of Hume in Germany', in *The Reception of David Hume in Europe*, ed. Peter Jones, London: Continuum, pp. 98–138.

(2006) 'Kant's Critical Philosophy and its reception: the first five years (1781–1786)', in *The Cambridge Companion to Kant and Modern Philosophy*, ed. Paul Guyer, Cambridge: Cambridge University Press, pp. 630–63.

Kusukawa, Sachiko (2000) 'The *Historia piscium* (1686)', *Notes and Records of the Royal Society*, 54, pp. 179–97.

Laeven, A. H. and Laeven-Aretz, L. J. M. (2014) *The Authors and Reviewers of the* Acta Eruditorum *1682–1735*, Molenhoek.

Laird, W. R. (1986) 'The Scope of Renaissance mechanics', *Osiris*, 2nd series, 2, pp. 43–68.

(2008) 'Nature, mechanics, and voluntary movement in Giuseppe Moletti's lectures on the Pseudo-Aristotelian *Mechanica*', in *Mechanics and Natural Philosophy before the Scientific Revolution*, eds. W. R. Laird and Sophie Roux, Dordrecht: Kluwer, pp. 173–83.

Lambert, Johann Heinrich (1764) *Neues Organon oder Gedancken über die Erforschung und Bezeichnung des Wahren und dessen Unterscheidung vom Irrthum und Schein*, Leipzig: Wendler.

La Mettrie, Julien Offray de (1748) *L'homme machine*, Leiden.

Lana Terzi, Francesco (1977 [1670]) *Prodromo all'Arte Maestra*, ed. Andrea Battistini, Milan: Longanesi.

Laporte, Jean Marie Frédéric (1950) *Le rationalisme de Descartes*, 2nd ed., revised and enlarged, Paris: Presses Universitaires de France.

Le Clerc, Jean (1709) 'Eloge de feu Mr. De Volder', *Bibliothèque choisie*, 18, pp. 346–401.

Leduc, Christian (2020) 'Speculative philosophy at the Berlin Academy', in *History of Universities*, vol. 33.2, eds. Mordechai Feingold and Andrea Sangiacomo, Oxford: Oxford University Press, pp. 175–200.

Le Grand, Antoine (1673) *Historia naturae, variis experimentis & ratiociniis elucidata secundum Principia stabilita in Institutione philosophiae edita ab eodem authore*, London.

(1694) *An Entire Body of Philosophy, According to the Principles of the Famous Renate Des Cartes*, London.

Lehmbrock, Verena (2016) 'Zur Geschichte einer Metakategorie: Das "Empirische" in der deutschen Ökonomischen Aufklärung und frühen Agrarwissenschaft um 1800', *Berichte zur Wissenschaftsgeschichte*, 29, pp. 79–98.

Leibniz, Gottfried Wilhelm (1875–90) *Die philosophischen Schriften von Gottried Wilhelm Leibniz*, 7 vols., ed. C. I. Gerhardt, Berlin: Weidmann.

(1969) *Gottfried Wilhelm Leibniz: Philosophical Papers and Letters*, 2nd ed., ed. Leroy E. Loemker, Dordrecht: D. Reidel.

(1971 [1669–70]) 'Grundriß eines Bedenckens von Aufrichtung einer Societät in Teutschland zu auffnehmen der Künste und Wißenschafften',

in Gottfried Wilhelm Leibniz, *Sämtliche Schriften und Briefe*, ed. Berlin-Brandenburgische Akademie der Wissenschaften and Akademie der Wissenschaften in Göttingen, Berlin: Akademie, 6th series, 1, pp. 530–43.

(1996) *New Essays on Human Understanding*, trans. Peter Remnant and Jonathan Bennett, Cambridge: Cambridge University Press.

(2001) *The Labyrinth of the Continuum: Writings on the Continuum Problem, 1672–1686*, ed. Richard T. W. Arthur, New Haven: Yale University Press.

(2007) *The Leibniz–Des Bosses Correspondence*, eds. Brandon C. Look and Donald Rutherford, New Haven: Yale University Press.

Leigh, Charles (1700) *Natural History of Lancashire, Cheshire and the Peak in Derbyshire*, Oxford.

Lémery, Nicolas (1677) *A Course of Chymistry*, London.

Le Monnier, Louis Guillaume (1742) *Leçons de physique expérimentale sur l'équilibre des liqueurs et sur la nature et les propriétés de l'air*, Paris.

Lennard, Reginald (1932) 'English agriculture under Charles II: the evidence of the Royal Society's "Enquiries"', *The Economic History Review*, 4, pp. 23–45.

de Lessaca, Juan Martin (1717) *Formas ilustradas a la luz de la razón*, Madrid: de Ariztia.

Levitin, Dmitri (2014a) 'The experimentalist as Humanist: Robert Boyle on the history of philosophy', *Annals of Science*, 71, pp. 149–82.

(2014b) 'Rethinking English physico-theology: Samuel Parker's *Tentamentia de deo* (1665)', *Early Science and Medicine*, 19, pp. 28–75.

(2015) *Ancient Wisdom in the Age of the New Science: Histories of Philosophy in England, c. 1640–1700*, Cambridge: Cambridge University Press.

(2019) 'Early modern experimental philosophy: a non-Anglocentric overview', in Vanzo and Anstey 2019, pp. 229–91.

Lhuyd, Edward (1695) *A Design of a British Dictionary, Historical and Geographical with an Essay, entituled, Archaelogia Britannica: and a Natural History of Wales*, Oxford.

(1697) *Parochial Queries in order to a Geographical Dictionary, A Natural History, &c. of Wales*, Oxford.

(1699) *Lithophilacii Britannica ichnographia*, Oxford.

Lindberg, David C. and Westman, Robert S., eds. (1990) *Reappraisals of the Scientific Revolution*, Cambridge: Cambridge University Press.

Lipton, Peter (2001) 'History of empiricism', in *International Encyclopedia of the Social & Behavioral Sciences*, eds. Neil J. Smelser and Paul B. Baltes, New York: Elsevier, pp. 4481–485.

Lister, John (2015) *The Correspondence of Dr. Martin Lister (1639–1677), Volume One: 1662–1677)*, ed. Anna Marie Roos, Leiden: Brill.

Llana, J. (2000) 'Natural history and the *Encyclopédie*', *Journal of the History of Biology*, 33, pp. 1–25.

Locke, John (1688) 'Review of Isaac Newton, *Philosophiae naturalis principia mathematica*', *Bibliothèque universelle et historique*, 8, pp. 436–50.

(1823) *The Works of John Locke*, 10 vols., London: Tegg.

(1954) *Essays on the Law of Nature*, ed. W. von Leyden, Oxford: Clarendon Press.
(1975) *An Essay concerning Human Understanding*, ed. Peter H. Nidditch, Oxford: Clarendon Press.
(1989 [1693]) *Some Thoughts Concerning Education*, eds. John W. Yolton and Jean S. Yolton, Oxford: Clarendon Press.
(1990) *Drafts for the* Essay Concerning Human Understanding *and Other Philosophical Writings*, 3 vols., eds. Peter H. Nidditch and G. A. J. Rogers, 1, Oxford: Clarendon Press.
Loeb, Luis E. (1981) *From Descartes to Hume: Continental Metaphysics and the Development of Modern Philosophy*, Ithaca: Cornell University Press.
Lohr, Charles H. (1988) 'The sixteenth-century transformation of the Aristotelian natural philosophy', in Kessler, Lohr, and Sparn 1988, pp. 89–99.
Longo, Mario (2008) 'Tradizioni storiografiche a confronto: Il passaggio dalla storiografia filosofica dell'illuminismo al kantismo', *Kant e-Prints*, 2nd series, 3, pp. 173–91, https://bit.ly/3CKCvV9.
(2011) 'A "Critical" History of Philosophy and the early Enlightenment: Johann Jacob Brucker', in Piaia and Santinello 2011, pp. 477–577.
(2015) 'The Göttingen School and *Popularphilosophie*', in Piaia and Santinello 2015, pp. 769–963.
Lossius, Johann Christian (1775) *Physische Ursachen des Wahren*, Gotha.
(1777) *Unterricht der gesunden Vernunft*, Gotha.
Loveland, Jeff (2001) *Rhetoric and Natural History: Buffon in Polemical and Literary Context*, Oxford: Voltaire Foundation.
Lowe, E. J. (1995) *Locke on Human Understanding*, London: Routledge.
Luce, A. A. (1934) *Berkeley and Malebranche: A Study in the Origins of Berkeley's Thought*, Oxford: Oxford University Press.
Lynn, Michael R. (2006) *Popular Science and Public Opinion in Eighteenth-Century France*, Manchester: Manchester University Press.
Lyon, John and Sloan, Phillip R., trans. (1981) *From Natural History to the History of Nature: Readings from Buffon and His Critics*, Notre Dame: University of Notre Dame Press.
McClaughlin, Trevor (1996) 'Was there an empirical movement in mid-seventeenth century France?', *Revue d'histoire des sciences*, 49, pp. 459–81.
McCracken, Charles J. (1983) *Malebranche and British Philosophy*, Oxford: Clarendon Press.
McGuire, J. E. (1968) 'The origin of Newton's doctrine of essential qualities', *Centaurus*, 12, pp. 233–60.
(1970) 'Newton's "Principles of Philosophy": an intended preface for the 1704 "Opticks" and a related draft fragment', *British Journal for the History of Science*, 5, pp. 178–86.
McGuire, J. E. and Tamny, Martin (1983) *Certain Philosophical Questions: Newton's Trinity Notebook*, Cambridge: Cambridge University Press.

Maclaurin, Colin (1748) *An Account of Sir Isaac Newton's Philosophical Discoveries*, London.

(1750) *An Account of Sir Isaac Newton's Philosophical Discoveries*, 2nd ed., London.

McMullin, Ernan (1976) 'The fertility of theory and the unit for appraisal in science', in *Essays in Memory of Imre Lakatos*, eds. Paul Feyerabend and Marx W. Wartofsky, Dordrecht: D. Reidel, pp. 395–432.

(1985) 'The significance of Newton's *Principia* for empiricism', in *Religion, Science and Worldview: Essays in Honor of Richard S. Westfall*, eds. Margaret J. Osler and Paul Farber, Cambridge: Cambridge University Press, pp. 33–59.

(2001) 'The impact of Newton's *Principia* on the philosophy of science', *Philosophy of Science*, 68, pp. 279–310.

Macor, Laura Anna (2011) *La fragilità della virtù: Dall'antropologia alla morale e ritorno nell'epoca di Kant*, Milan: Mimesis.

Magalotti, Lorenzo (1667) *Saggi di naturali esperienze fatte nell'Accademia del Cimento*, Florence.

Magirus, Johannes (1619) *Physiologiae peripateticæ libri sex*, London.

Maimon, Salomon (2004 [1790]) *Versuch über die Transzendentalphilosophie*, ed. Florian Ehernsperger, Hamburg: Meiner; trans. as *Essay on Transcendental Philosophy*, trans. Alistar Welchman et al., London: Continuum, 2010.

Malebranche, Nicolas (1674) *De la recherche de la vérité*, vol. 1, Paris.

(1997 [1712]) *The Search after Truth*, trans. Thomas M. Lennon and Paul J. Olscamp, Cambridge: Cambridge University Press (6th ed. of *De la recherche de la vérité*).

Malik, Saira (2017) 'Observation versus experiment: an adequate framework for analysing scientific experimentation?', *Journal for General Philosophy of Science*, 48, pp. 71–95.

Malpighi, Marcello (1980 [1698]) 'Risposta del Dottor Marcello Malpighi alla lettera intitolata: "De recentiorum medicorum studio dissertatio epistolaris ad amicum"', in Altieri Biagi and Basile 1980, pp. 1065–184.

Mancosu, Paolo (1996) *Philosophy of Mathematics and Mathematical Practice in the Seventeenth Century*, Oxford: Oxford University Press.

Manning, Gideon (2012) 'Three biased reminders about hylomorphism in early modern science and philosophy', in *Matter and Form in Early Modern Science and Philosophy*, ed. Gideon Manning, Leiden: Brill, pp. 1–32.

Manzo, Silvia (2016) 'Empirismo y filosofía experimental: Las limitaciones del relato estándar de la filosofia moderna a la luz de la historiografia francesa del siglo XIX (J.-M. Degérando)', *Revista Colombiana de Filosofía de la Ciencia*, 26, pp. 11–35.

Mariétan, Joseph (1901) *Problème de la classification des sciences d'Aristote à St-Thomas*, Valais: St-Augustin.

Mariotte, Edme (1678) *Essai de Logique*, Paris.

Markie, Peter J. (2021) 'Rationalism vs. Empiricism', in *The Stanford Encyclopedia of Philosophy* (Fall 2021 ed.), ed. Edward N. Zalta, https://stanford.io/3T8dfOe.

Martin, Craig (2011) *Renaissance Meteorology: Pomponazzi to Descartes*, Baltimore: Johns Hopkins University Press.

Martin, Martin (1703) *A Description of the Western Islands of Scotland*, London.

Matei, Oana (2017) 'Reconstructing *Sylva Sylvarum:* Ralph Austen's *Observations* and the use of experiment', *Journal of Early Modern Studies*, 6, pp. 91–115.

(2018) 'Appetitive matter and perception in Ralph Austen's projects of natural history of plants', *Early Science and Medicine*, 23, pp. 530–49.

Mauchart, Immanuel David (1789) *Phänomene der menschlichen Seele: Eine Materialien-Sammlung zur künftigen Aufklärung in der Erfahrungs-Seelenlehre*. Stuttgart.

(1792) 'Vorrede', in Mauchart 1792–1801, 1, pp. iii–xvii.

Mauchart, Immanuel David, ed. (1792–1801) *Allgemeines Repertorium für empirische Psychologie und verwandte Wissenschaften*, 6 vols., Nuremberg.

Maupertuis, Pierre-Louis Moreau de (1742) *Discours sur les différentes figures de astres*, 2nd ed., Paris.

(1748) 'Les loix du movement et du repos déduites d'un principe metaphysique', *Histoire de L'Académie Royale des Sciences et Belles Lettres*, 1746, Berlin, pp. 267–94.

(1750) 'Des devoirs de l'academicien', *Histoire de L'Académie Royale des Sciences et Belles Lettres*, 1750, Berlin, pp. 115–25.

(1768) *Œuvres de Maupertuis*, 4 vols., Lyon.

Maurolico (or Maurolyco), Francesco (1613) *Problemata Mechanica cum appendice, & ad Magnetem, & ad Pix idem Nauticam pertinentia*, Messina.

Maynwaring, Everard (1668) *Medicus Absolutus ΑΔΕΣΠΟΤΟΣ, The Compleat Physician*, London.

Meier, Georg Friedrich (1754–9) *Anfangsgründe aller schönen Wissenschaften*, 2nd ed., 3 vols., Halle.

(1924 [1752]) *Auszug aus der Vernunftlehre*, in Kant 1900–, vol. 16.

Meiners, Christoph (1772) *Revision der Philosophie*, vol. 1 (only published), Göttingen.

(1781–2) *Geschichte des Ursprungs, Fortgangs und Verfalls der Wissenschaften in Griechenland und Rom*, 2 vols., Lemgo.

(1786a) *Grundriß der Geschichte der Weltweisheit*, Lemgo.

(1786b) *Grundriß der Seelen-Lehre*, Lemgo.

Mendelssohn, Moses (1786) *Moses Mendelssohns Morgenstunden oder Vorlesungen über das Daseyn Gottes*, vol. 1, Berlin: Voß, trans. as *Morning Hours: Lectures on God's Existence*, trans. Daniel O. Dahlstrom and Corey Dyck, Amsterdam: Springer, 2011.

Merrett, Christopher (1679) 'The art of refining', *Philosophical Transactions*, 12.142, pp. 1047–51.

Micheli, Giuseppe (1982) *Kant, storico della filosofia*, Padua: Antenore.

(1990) 'The early reception of Kant's thought in England 1785–1805', in *Kant and His Influence*, eds. George MacDonald Ross and Tony McWalter, Bristol: Thoemmes, pp. 202–314.
(1992) *Tennemann: storico della filosofia*, Padua: CLEUP, repr. in Santinello and Piaia 1995, pp. 413–509.
(2015) 'Philosophy and historiography: The Kantian turning-point', in Piaia and Santinello 2015, pp. 697–768.
Micheli, Giuseppe et al. (2015) 'Kantianism and the historiography of philosophy', in Piaia and Santinello 2015, pp. 515–693.
Middleton, W. E. Knowles (1963) 'The place of Torricelli in the history of the barometer', *Isis*, 54, pp. 11–28.
Mikkeli, Heikki (2001) 'The Aristotelian classification of knowledge in the early sixteenth century', in Pade 2001, pp. 102–27.
Miller, Gordon (2008) 'Beasts of the Divine Jerusalem: John Johnston's Natural History and the launching of millenarian pedagogy in the seventeenth century', *History of Science*, 46, pp. 203–43.
Milton, J. R. (1984) 'The Scholastic background to Locke's thought', *The Locke Newsletter*, 15, pp. 25–34.
Moll, Konrad (1982) *Der junge Leibniz*, vol. 2: *Des Übergang vom Atomismus zu einem mechanistischen Aristotelismus: Der revidierte Anschluß an Pierre Gassendi*, Stuttgart: Frommann-Holzboog.
Molyneux, Thomas (1694) 'Dr. Molineux's historical account of the late general coughs and colds; with some observations on other epidemick distempers', *Philosophical Transactions*, 18.208, pp. 105–11.
Molyneux, William (1684) 'A Letter from William Molyneux Esq. Secretary of the Philosophical Society of Dublin, to a S. of the R. S. Giving an account of the Connough-Worm', *Philosophical Transactions*, 15.168, pp. 876–9.
(1692) *Dioptrica nova*, London.
Monantheuil, Henri de (1599) *Aristotelis Mechanica Graeca, emendata, Latina facta, & Commentariis illustrate*, Paris.
Montanari, Geminiano (1667) *Pensieri fisico-matematici sopra alcune esperienze . . . intorno diversi effetti de' liquidi in cannuccie di vetro, & altri vasi*, Bologna.
(1671) *Speculazioni fisiche [. . .] Sopra gli effetti di que' Vetri Temprati, che rotti in una parte si risolvuono tutti in polvere*, Bologna.
(1676) *La fiamma volante*, Bologna.
(1694 [1675]) 'Discorso del vacuo', in *Le forze d'Eolo*. Parma, pp. 271–312.
(1780) *Alcune Esperienze [. . .] sopra l'Equilibrio di diversi Liquidi in alcuni Vasi [. . .], in Notizie degli aggrandamenti delle scienze fisiche accaduti in Toscana nel corso di anni LX del secolo XVII*, 5 vols., ed. Giovanni Targioni Tozzetti, Florence, 1780, 2, pp. 721–34.
(1971) 'Dalla "Compendiosa introductio at physicam experimentalem"', in *Miscellanea Seicento*, 2 vols., Florence: Le Monnier, 2, pp. 197–201.

(1980) 'Della natura et uso degli atomi o sia corpuscoli appresso i moderni: Trattato primo fisico-matematico del Sig. Geminiano Montanari', in Altieri Biagi and Basile 1980, pp. 537–52.

Montesquieu, Charles Louis de Secondat (1989) *The Spirit of the Laws*, eds. Anne M. Cohler, Basia C. Miller, and Harold S. Stone, Cambridge: Cambridge University Press.

Morell, Thomas (1827) *Elements of the History of Philosophy and Science, from the Earliest Authentic Records to the Commencement of the Eighteenth Century*, London: Holdsworth.

Morison, Robert (1669) *Hortus regius Blesensis auctus*, London.

(1680) *Plantarum historiae universalis Oxoniensis pars secunda*, Oxford.

(1699) *Plantarum historiae universalis Oxoniensis pars tertia*, Oxford.

Moritz, Karl Philipp (1782a) *Aussichten zu einer Experimentalseelenlehre*, Berlin.

(1782b) 'Vorschlag zu einem Magazin einer Erfahrungs-Seelenkunde', *Deutsches Museum*, 1, pp. 485–503.

Morton, A. Q. (1990) 'Lectures on natural philosophy in London, 1750–1765: S. C. T. Demainbray (1710–1782) and the "Inattention" of his countrymen', *British Journal for the History of Science*, 23, pp. 411–34.

Mühlpfordt, Günter (1989) 'Die organischen Naturwissenschaften in Wolffs empiriorationalistischer Enzyklopädistik', *Il cannocchiale*, pp. 77–106, repr. in Carboncini and Cataldi Madonna 1992, pp. 96–103.

Murray, Gemma, Harper, William, and Wilson, Curtis (2011) 'Huygens, Wren, Wallis, and Newton on rules of impact and reflection', in *Vanishing Matter and the Laws of Motion*, eds. Dana Jalobeanu and Peter R. Anstey, New York: Routledge, pp. 153–91.

Nagel, Fritz (2005) '*Scientia experimentalis*: Zur Cusanus-Rezeption in England', *Mitteilungen und Forschungsbeiträge der Cusanus-Gesellschaft*, 29, pp. 95–109.

Nakano, Yasuaki (2021) 'Berkeley's experimental method in *An Essay Towards a New Theory of Vision*', in *Locke on Knowledge, Politics and Religion: New Interpretations from Japan*, eds. Kiyoshi Shimokawa and Peter R. Anstey, London: Bloomsbury, pp. 74–98.

Naragon, Steve (online), *Kant in the Classroom: Materials to Aid the Study of Kant's Lectures*, https://bit.ly/3fOSYP7.

Nedham, Marchamont (1665) *Medela medicinæ*, London.

Newman, William R. (2006) *Atoms and Alchemy: Chymistry and the Experimental Origins of the Scientific Revolution*, Chicago: University of Chicago Press.

Neri, Antonio (1662) *The Art of Glass*, London.

Newton, Sir Isaac (1672a) 'A letter of Mr. Isaac Newton, Professor of the Mathematicks in the University of Cambridge; containing his New Theory about light and colors', *Philosophical Transactions*, 6.80, pp. 3075–87.

(1672b) 'Some experiments propos'd in relation to Mr Newtons Theory of light, ... together with the observations made thereupon by the author', *Philosophical Transactions*, 7.83, pp. 4059–62.

(1672c) 'A serie's of Quere's propounded by Mr. Isaac Newton, to be determin'd by Experiments, positively and directly concluding his new theory of light and colours', *Philosophical Transactions*, 7.85, pp. 5004–7.
(1672d) 'Mr. Isaac Newtons answer to some considerations upon his Doctrine of Light and Colors', *Philosophical Transactions*, 7.88, pp. 5084–103.
(1704) *Opticks*, London.
(1706) *Optice*, London.
(1713) *Philosophiae naturalis principia mathematica*, 2nd ed., London.
(1715) 'An account of the book entituled Commercium Epistolicum Collinii & aliorum, De Analysi promota', *Philosophical Transactions*, 29.342, pp. 173–224. Published anonymously.
(1959–77) *The Correspondence of Isaac Newton*, 7 vols., eds. W. H. Turnbull, J. F. Scott, A. Rupert Hall, and Laura Tilling, Cambridge: Cambridge University Press.
(1979) *Opticks*, ed. I. Bernard Cohen, New York: Dover. 4th ed. 1730.
(1984) *The Optical Papers of Isaac Newton: The Optical Lectures 1670–1672*, ed. Alan E. Shapiro, Cambridge: Cambridge University Press.
(1999) *The Principia: Mathematical Principles of Natural Philosophy*, eds. I. Bernard Cohen and Anne Whitman, Berkeley: University of California Press.
(2014) *Newton: Philosophical Writings*, revised ed., ed. Andrew Janiak, Cambridge: Cambridge University Press.
Nickles, Thomas (2005) 'Empiricism', in *New Dictionary of the History of Ideas*, ed. Maryanne Cline Horowitz, 6 vols., Detroit: Scribner's Sons, 2, pp. 664–9.
Nieuwentijt, Bernard (1715) *Het regt gebruik der wereldbeschouwing*, Amsterdam.
(1718) *The Religious Philosopher: or, the Right Use of Contemplating the Works of the Creator*, trans. John Chamberlayne, 3 vols., London.
Nollet, Jean-Antoine (1735) *Cours de physique expérimentale chez M. l'abbé Nollet*, Paris.
(1738) *Programme ou idée générale d'un cours de physique expérimentale*, Paris.
(1759) *Leçons de physique expérimentale*, vol. 1, 5th ed., Paris.
Norton, David Fate (1981) 'The myth of British Empiricism', *History of European Ideas*, 1, pp. 331–44.
Nyden, Tammy (2013) 'De Volder's Cartesian physics and experimental pedagogy', in Dobre and Nyden 2013a, pp. 227–49.
Oberhausen, Michael (1997) *Das neue Apriori: Kants Lehre von einer ursprünglicher Erwerbung apriorischer Vorstellungen*, Stuttgart: Frommann-Holzboog.
Oberhausen, Michael and Pozzo, Riccardo, eds. (1999) *Vorlesungsverzeichnisse der Universitat Königsberg (1720–1804)*, Stuttgart: Frommann-Holzboog.
Ochs, Kathleen H. (1985) 'The Royal Society of London's History of Trades programme: an early episode in applied science', *Notes and Records of the Royal Society*, 39, pp. 129–58.

Ogilvie, Brian W. (2005) 'Natural history, ethics, and physico-theology', in Pomata and Siraisi 2005, pp. 75–103.
(2006) *The Science of Describing: Natural History in Renaissance Europe*, Chicago: University of Chicago Press.
Oldenburg, Henry (1666a) 'Preface', *Philosophical Transactions*, 1.8, pp. 140–1.
(1666b) 'Review of Robert Boyle, *Origin of Forms and Qualities*', *Philosophical Transactions*, 1.11, pp. 191–7.
(1669) 'A preface to this fifth year of the Transactions', *Philosophical Transactions*, 4.45, pp. 893–8.
(1672) 'A preface to the eighth year', *Philosophical Transactions*, 7.81, pp. 4000–3.
(1965–86) *The Correspondence of Henry Oldenburg*, 13 vols., eds. A. Rupert and Marie Boas Hall. Madison, Milwaukee, and London: University of Wisconsin Press, Mansell, and Taylor and Francis.
Oldroyd, David R. (1980) 'Some "Philosophicall Scribbles" attributed to Robert Hooke', *Notes and Records of the Royal Society of London*, 35, pp. 17–32.
(1987) 'Some writings of Robert Hooke on procedures for the prosecution of scientific inquiry, including his "Lectures of Things Requisite to a Natural History"', *Notes and Records of the Royal Society*, 41, pp. 145–67.
Pade, Marianne, ed. (2001) *Renaissance Readings of the Corpus Aristotelicum*, Copenhagen: Museum Tusculanum Press.
Palmerino, Carla Rita (2012) 'The composition of space, time and matter according to Isaac Newton and John Keill', in Garber and Roux 2013, pp. 117–42.
Papadimitriou, E. (1981) 'Zu den philosophiegeschichtlichen Voraussetzungen der Kantischen Kritik der reinen Vernunft', in *Akten des 4. Internationalen Kant-Kongresses: Mainz. 4.-8. April 1981*, ed. Gerhard Funke, 2 vols., Berlin: de Gruyter, 1.1, pp. 39–47.
Park, Katharine and Daston, Lorraine, eds. (2006) *The Cambridge History of Science*, vol. 3: *Early Modern Science*, Cambridge: Cambridge University Press.
Parker, Samuel (1665) *Tentamina physico-theologica de Deo*, London.
(1666) *A Free and Impartial Censure of the Platinick Philosophie*, Oxford.
Parkin, Jon (1999) *Science, Religion and Politics in Restoration England: Richard Cumberland's* De legibus naturae, Woodbridge: Boydell Press.
Parkinson, G. H. R. (1993), *The Renaissance and Seventeenth-Century Rationalism: Routledge History of Philosophy*, vol. 4, London: Routledge.
Pascal, Blaise (1995 [1670]) *Pensées and Other Writings*, ed. H. Levi, Oxford: Oxford University Press.
Pasnau, Robert (2017) *After Certainty: A History of Our Epistemic Ideals and Illusions*, Oxford: Oxford University Press.
Patrick, Simon (1662) *A Brief Account of the New Sect of Latitude-Men together with some Reflections upon the New Philosophy*, London.
Pépin, François (2012) *La philosophie expérimentale de Diderot et chimie*, Paris: Classiques Garnier.

Pepys, Samuel (1933) *Letters and the Second Diary of Samuel Pepys*, ed. R. G. Howarth, London: J. M. Dent and Sons.

Perrault, Claude (1671–6) *Mémoires pour Servir à l'Histoire Naturelle des Animaux*, 2 vols., Paris.

(1680) *Essais de physique*, vol. 1, Paris.

Perrin, Jean (1910) *Brownian Movement and Molecular Reality*, trans. Frederick Soddy, London: Taylor and Francis.

Pestre, Abbé Jean (1752) 'Baconisme', in *Encyclopédie*, vol. 2, eds. Denis Diderot and Jean Le Rond d'Alembert, Paris, 1751–72, pp. 8–10.

Petrocchi, Ivano (2004) *Lockes Nachlaßschrift* of the Conduct of the Understanding *und ihr Einfluß auf Kant: Das Gleichgewicht des Verstandes. Zum Einfluß des späten Locke auf Kant und die deutsche Aufklärung*, Frankfurt a.M.: Olms.

Pett, Sir Peter (1688) *The Happy Future State of England*, London.

Petty, Sir William (1967) *The Petty Papers*, vol. 1, New York: Augustus M. Kelley.

Phemister, Pauline and Brown, Stuart, eds. (2007) *Leibniz and the English-Speaking World*, Dordrecht: Springer.

Piaia, Gregorio (1996) 'European identity and national characteristics in the *Historia philosophica* of the seventeenth and eighteenth centuries', *Journal of the History of Philosophy*, 34, pp. 593–605.

(2004) 'La storia della filosofia come "nomenclatura dei sistemi": Joseph-Marie Degérando', in Santinello and Piaia 1995, pp. 5–87.

Piaia, Gregorio and Santinello, Giuseppe, eds. (2011) *Models of the History of Philosophy*, vol. 2: *From the Cartesian Age to Brucker*, Dordrecht: Springer.

(2015) *Models of the History of Philosophy*, vol. 3: *The Second Enlightenment and the Kantian Age*, Dordrecht: Springer.

Piccolomini, Alessandro (1565) 'Praefatio', in *In mechanicas quaestiones Aristotelis, Paraphrasis paulo quidem plenior*, 2nd ed., Venice.

Pico della Mirandola, Giovanni (1965 [1486]) *On the Dignity of Man*, in *On the Dignity of Man; On Being and the One; Heptaplus*, trans. C. G. Wallis, Indianapolis: Bobbs-Merrill.

(1998 [1486]) *Conclusiones Nongentae,* in *Syncretism in the West: Pico's 900 Theses (1486). The Evolution of Traditional, Religious, and Philosophical Systems*, ed. and trans. S. A. Farmer, Tempe, AZ: Medieval & Renaissance Texts & Studies.

Pistorius, Hermann Andreas (1789) 'Review of Carl Christian Erhard Schmid, *Critik der reinen Vernunft im Grundrisse* and *Wörterbuch zum leichtern Gebrauch der Kantischen Schriften*, 2nd ed.', *Allgemeine deutsche Bibliothek*, 88 (1), pp. 104–22; trans. 'On Carl Christian Erhard Schmid's essay about Kant's Purism and Selle's Empiricism', in Sassen 2000b, pp. 255–69. Published anonymously.

Platner, Ernst (1772) *Anthropologie für Aerzte und Weltweise*, vol. 1, Leipzig: Dyck, repr. 2000.

(1790) *Neue Anthropologie für Aerzte und Weltweise: Mit besonderer Rücksicht auf Physiologie, Pathologie, Moralphilosophie und Aesthetik*, vol. 1, Leipzig.

(1793) *Philosophische Aphorismen: Nebst einigen Anleitungen zur philosophischen Geschichte*, vol. 1, Leipzig, repr. 1970.

Plot, Robert (1674) *Quar's to be Propounded to the Most Ingenious of each County in my Travels through England*, [Oxford].

(1677) *The Natural History of Oxford-Shire*, Oxford.

(1685) 'A letter from Dr. Robert Plot of Oxford, to Dr Martin Lister ... concerning the use which may be made of the following History of the Weather, made by him at Oxford through out the year 1684', *Philosophical Transactions*, 15.169, pp. 930–43.

(1686) *The Natural History of Stafford-Shire*, Oxford.

Pockels, Carl Friedrich (1794) *Denkwürdigkeiten zur Bereicherung der Erfahrungsseelenlehre*, vol. 1. Halle: Renger.

Pocock, J. G. A. (1999) *Barbarism and Religion*, vol. 1: *The Enlightenments of Edward Gibbon, 1737–1764*, Cambridge: Cambridge University Press.

Poggi, Davide (2007) 'L'*Essay* di J. Locke e la *Psychologia empirica* di Christian Wolff', in *Christian Wolff tra psicologia empirica e psicologia razionale: Atti del seminario internazionale di studi, Verona, 13–14 maggio 2005*, ed. Ferdinando Luigi Marcolungo = Wolff 1962–, sect. 3, vol. 106, Hildesheim: Olms, pp. 63–94.

Polinière, Pierre (1709) *Expériences de physique*, Paris.

(1718) *Expériences de physique*, 2nd ed., Paris.

Poliziano, Angelo (1553 [1491]) 'Praelectio, cui titulus Panepistemon', in *Opera*, Basel, pp. 462–73.

Pollok, Konstantin (2004) 'Die Locke-Rezeption in der deutschen Aufklärung: Frühe lateinische und deutsche Übersetzungen von Lockes Werken (1709–61)', in *Locke in Germany: Early German Translations of John Locke, 1709–61*, 8 vols., ed. Konstantin Pollok, Bristol: Thoemmes Continuum, 1, pp. v–xxxviii.

Pomata, Gianna (2010) 'Sharing cases: the *Observationes* in early modern medicine', *Early Science and Medicine*, 15, pp. 193–236.

(2011a) 'A word of empirics: the ancient concept of observation and its recovery in early modern medicine', *Annals of Science*, 68, pp. 1–25.

(2011b) 'Observation rising: birth of an epistemic genre, 1500–1650', in Daston and Lunbeck 2011, pp. 45–80.

Pomata, Gianna and Siraisi, Nancy G., eds. (2005) Historia*: Empiricism and Erudition in Early Modern Europe*, Cambridge, MA: MIT Press.

Ponce de Santa Cruz, Antonio (1624) 'De natura Medicinæ', in *Opuscula medica et philosophica*, Madrid, pp. 1–5.

Poovey, Mary (1998) *A History of the Modern Fact: Problems of Knowledge in the Sciences of Wealth and Society*, Chicago: University of Chicago Press.

Popkin, Richard (1959) 'Did Hume ever read Berkeley?', *Journal of Philosophy*, 56, pp. 533–45.

(1980) 'Randall and British Empiricism', in *The High Road to Pyrrhonism*, eds. Richard A. Watson and James E. Force, San Diego: Austin Hill, pp. 39–53.

Powell, William (1746) *The Heads of a Course of Lectures in Experimental Philosophy*, Cambridge.

(1753) *The Heads of a Course of Lectures in Experimental Philosophy*, Cambridge.
Power, Henry (1664) *Experimental Philosophy*, London.
Pozzo, Riccardo (1998) 'Review of Hans-Jürgen Engfer, *Empirismus versus Rationalismus?*', *Review of Metaphysics*, 52, pp. 441–2.
Priest, Stephen (2007) *The British Empiricists*, 2nd ed., London: Routledge.
Priestley, Joseph (1775) *Philosophical Empiricism: containing Remarks on a Charge of Plagiarism respecting Dr H—s*, London.
Puech, Michel (1992) 'Tetens et la crise de la métaphysique allemande en 1775 (Über die allgemeine speculativische Philosophie)', *Revue philosophique de la France et de l'étranger*, 1, pp. 3–29.
Pufendorf, Samuel (1660) *Elementorum jurisprudentiae universalis*, The Hague.
(1672) *De jure naturae et gentium*, Lund.
Pumfrey, Stephen, Rayson, Paul, and Mariani, John (2012) 'Experiments in 17th century English: manual versus automatic conceptual history', *Literary and Linguistic Computing*, 27, pp. 395–408.
Rappaport, Rhoda (1986) 'Hooke on earthquakes: lectures, strategy and audience', *British Journal for the History of Science*, 19, pp. 129–46.
Raven, C. E. (1950) *John Ray: Naturalist*, 2nd ed., Cambridge: Cambridge University Press.
Ray, John (1686) *Historia Plantarum . . . tomus primus*, London.
(1688) *Historia Plantarum tomus secundus*, London.
(1704) *Historia Plantarum tomus tertius*, London.
Redi, Francesco (1909 [1668]) *Experiments on the Generation of Insects*, ed. Mab Bigelow, Chicago: Open Court.
Rees, Graham (2004) 'Bacon as you never knew him: on Francis Bacon's originality', *Intellectual News*, 14, pp. 69–73.
Reid, Thomas (1995) *Thomas Reid on the Animate Creation*, ed. Paul Wood, Edinburgh: Edinburgh University Press.
(2002) *The Correspondence of Thomas Reid*, ed. Paul Wood, Edinburgh: Edinburgh University Press.
(2007) *Thomas Reid on Practical Ethics: Lectures and Papers on Natural Religion, Self-Government, Natural Jurisprudence and the Law of Nations*, ed. Knud Haakonssen, Edinburgh: Edinburgh University Press.
(2010) *Essays on the Active Powers of Man*, eds. Knud Haakonssen and James Harris, Edinburgh: Edinburgh University Press.
Reif, P. (1969) 'The textbook tradition in natural philosophy, 1600–1650', *Journal of the History of Ideas*, 30, pp. 17–32.
Reinhold, Karl Leonhard (1789) *Versuch einer neuen Theorie des menschlichen Vorstellungsvermögens*, Prague: Witmann und Mauke; trans. as *Essay on a New Theory of the Human Capacity for Representation*, trans. Tim Mehigan and Barry Empson, Berlin: de Gruyter, 2011.
(1791) 'Über den Begriff der Geschichte der Philosophie: Eine Akademische Vorlesung', *Beyträge zur Geschichte der Philosophie*, 1, pp. 3–36.

(1792) 'Review of Judwig Henrich Jakob, *David Hume über die menschliche Natur', Allgemeine Literatur-Zeitung*, 174 (175) (July 1792), pp. 17–32. Published anonymously.

(2003 [1790]) *Beiträge zur Berichtigung bisheriger Missverständnisse der Philosophen*, vol. 1: *Erster Band, das Fundament der Elementarphilosophie betreffend*, ed. Faustino Fabbianelli, Hamburg: Meiner.

(2004 [1794]) *Beiträge zur Berichtigung bisheriger Missverständnisse der Philosophen*, vol. 2: *Zweiter Band, die Fundamente des philosophischen Wissens, der Metaphysik, Moral, moralischen Religion und Geschmackslehre betreffend*, ed. Faustino Fabbianelli, Hamburg: Meiner.

(2007–) *Gesammelte Schriften: Kommentierte Ausgabe*, ed. Martin Bondeli, Basel: Schwabe.

(2007 [1790]) *Briefe über die Kantische Philosophie*, vol. 1, in Reinhold 2007–, vol. 2.1.

(2008 [1792]) *Briefe über die Kantische Philosophie*, vol. 2, in Reinhold 2007–, vol. 2.2.

(2011 [1791]) *Ueber das Fundament des philosophischen Wissens nebst einigen Erläuterungen über die Theorie des Vorstellungsvermögen*, in Reinhold 2007–, vol. 4; partial trans. as *The Foundation of Philosophical Knowledge: Together with Some Comments Concerning the Theory of the Faculty of Representation*, trans. George di Giovanni, in Di Giovanni and Harris 1985, pp. 52–103.

Rescher, Nicholas (1979) *Leibniz: An Introduction to His Philosophy*, Oxford: Basil Blackwell.

(1980) 'The epistemology of inductive reasoning in Leibniz', in *Theoria cum praxi: Zum Verhältnis von Theorie und Praxis im 17. und 18. Jahrhundert. Akten des 3. Internationalen Leibnizkongresses, Hannover, 12–17 November 1977*, vol. 3: *Logik, Erkenntnistheorie, Wissenschaftstheorie, Metaphysik, Theologie*, eds. Kurt Müller, Heinrich Schepers, and Wilhelm Totok, *Studia Leibnitiana Supplementa*, 21, Wiesbaden: Steiner, pp. 94–100.

Reuß, Matern (1789) *Soll man auf katholischen Universitäten Kants Philosophie erklären?*, Würzburg.

Robertson, Haileigh (2020) 'A gunpowder controversy in the early Royal Society, 1667–70', *Notes and Records*, 74, pp. 73–94.

Robinson, H. W. (1949) 'An unpublished letter of Dr Seth Ward relating to the early meetings of the Oxford Philosophical Society', *Notes and Records of the Royal Society*, 7, pp. 68–70.

Robinson, Thomas (1696) *New Observations on the Natural History of this World of Matter and World of Life*, London.

Roche, Daniel (1996) 'Natural history in the academies', in *Cultures of Natural History*, eds. N. Jardine, J. A. Secord, and E. C. Spary, Cambridge: Cambridge University Press, pp. 127–44.

Rohault, Jacques (1671) *Traité de physique*, Paris.

(1710) *Jacobi Rohaulti physica*, London.

(1723) *Rohault's System of Natural Philosophy, Illustrated with Dr Samuel Clarke's Notes*, 2 vols., London.

Roos, Anna Marie (2011) *Web of Nature: Martin Lister (1639–1712): The First Arachnologist*, Leiden: Brill.

Rorty, Richard (1979) *Philosophy and the Mirror of Nature*, Princeton: Princeton University Press.

Ross, George MacDonald (2007) 'Leibniz's debt to Hobbes', in Phemister and Brown 2007, pp. 19–33.

Ross, Sydney (1962) '*Scientist*: The story of a word', *Annals of Science*, 18, pp. 65–85.

Rossi, Paolo (1970) *Philosophy, Technology, and the Arts in the Early Modern Era*, ed. B. Nelson, trans. S. Attanasi, New York: Harper & Row.

Roux, Sophie (2013a) 'An empire divided: French natural philosophy (1670–1690)', in Garber and Roux 2013, pp. 55–95.

(2013b) 'Was there a Cartesian experimentalism in 1660s France?', in Dobre and Nyden 2013a, pp. 47–88.

(2017) 'The two comets of 1664–1665: a dispersive prism for French natural philosophical principles', in Anstey 2017a, pp. 98–146.

Rumore, Paola (2007) *L'ordine delle idee: La genesi del concetto di rappresentazione in Kant attraverso le sue fonti wolffiane*, Florence: Le Lettere.

Rusnock, Andrea (2002) *Vital Accounts: Quantifying Health and Population in Eighteenth-Century England and France*, New York: Cambridge University Press.

Russell, Bertrand (1945) *A History of Western Philosophy and Its Connection with Political and Social Circumstances from the Earliest Times to the Present Day*, New York: Simon and Schuster.

Russiliano Sesto, Tiberio (1991 [1519]), *Apologeticus adversus cucullatos*, ed. Luigi De Franco, Cosenza: Periferia.

Ryle, Gilbert (2005 [1960]) 'Epistemology', in *The Concise Encyclopedia of Western Philosophy*, eds. Jonathan Rée and J. O. Urmson, 3rd ed., London: Routledge, pp. 112–20.

Salomon-Bayat, C. (1978) *L'institution de la science et l'expérience du vivant*, Paris: Flammarion.

Santinello, Giovanni (1965) 'Kant e Tennemann: considerazioni sulla storia della filosofia', in *Metafisica e critica in Kant*, Bologna: Patron, pp. 317–33.

(1988) 'Il kantismo nell'opera storiografica di J. G. Buhle', in *Storia delle storie generali della filosofia*, ed. Giovanni Santinello, Padua: Antenore, 3, pp. 959–1019.

Santinello, Giovanni and Piaia, Gregorio, eds. (1995) *Storia delle storie generali della filosofia*, vol. 4: *L'età hegeliana*, part 1: *La storiografia filosofia nell'area tedesca*, Padua: Antenore.

Sargent, Rose-Mary (1995) *The Different Naturalist: Robert Boyle and the Philosophy of Experiment*, Chicago: University of Chicago Press.

Sassen, Brigitte (2000a) 'Introduction: major trends in the early empiricist reception of Kant's Critical Philosophy', in Sassen 2000b, pp. 1–49.

Sassen, Brigitte, ed. and trans. (2000b) *Kant's Early Critics: The Empiricist Critique of the Theoretical Philosophy*, Cambridge: Cambridge University Press.

Sassen, Brigitte (2015) '18th Century German philosophy prior to Kant', in *The Stanford Encyclopedia of Philosophy* (Summer 2015 ed.), ed. Edward N. Zalta, https://stanford.io/3T8JpsL.

Schaumann, Johann Christian Gottlieb (1789) *Ueber die transcendentale Aesthetik: Ein kritischer Versuch. Nebst einem Schreiben an Herrn Hofrath Feder über den transcendentalen Idealismus*, Leipzig, repr. 1968.

Scheibler, Christoph (1639) *Philosophia compendiosa*, 6th ed., revised and enlarged, Oxford.

Schickore, Jutta (2010) 'Trying again and again: multiple repetitions in early modern reports of experiments on snake bites', *Early Science and Medicine*, 15, pp. 567–617.

(2011) 'The significance of re-doing experiments: a contribution to historically informed methodology', *Erkenntnis*, 75, pp. 325–47.

(2017) *About Method: Experimenters, Snake Venom, and the History of Writing Scientifically*, Chicago: University of Chicago Press.

Schliesser, Eric (2018) 'Four methods of empirical inquiry in the aftermath of Newton's challenge', in Bodenmann and Rey 2018a, pp. 15–30.

Schmaltz, Tad (2016) *Early Modern Cartesianisms: Dutch and French Constructions*, Oxford: Oxford University Press.

Schmauke, Stephan (2002) *Wohlthätigste Verirrung: Kants kosmologische Antinomien*, Würzburg: Königshausen & Neumann.

Schmid, Carl Christian Ehrard (1788a) 'Einige Bemerkungen über den Empirismus und Purismus in der Philosophie: Durch die Grundsätze der reinen Philosophie von Herrn Selle veranlaßt', in Schmid 1788b; trans. as 'Some Remarks about Empiricism and Purism in Philosophy Occasioned by Selle's Principles of Pure Philosophy', in Sassen 2000b, pp. 233–54.

(1788b) *Wörterbuch zum leichtern Gebrauch der Kantischen Schriften: Nebst einer Abhandlung*, 2nd ed., enlarged, Jena.

(1788c) *Critik der reinen Vernunft im Grundrisse*, 2nd revised ed., Jena: Cröcker.

(1790) *Versuch einer Moralphilosophie*, Jena.

Schmitt, Charles B. (1982) 'Review of Robert Frank, *Harvey and the Oxford Physiologists*', *Isis*, 73, pp. 432–3.

Schmitt, Charles B., Skinner, Quentin, and Kessler, Eckhard, eds. (1988) *The Cambridge History of Renaissance Philosophy*, Cambridge: Cambridge University Press.

Schultz, Johann (1784) *Erläuterungen über des Herrn Professor Kants Critik der reinen Vernunft*, Königsberg.

(1789) *Prüfung der kantischen Critik der reinen Vernunft*, vol. 2, Königsberg, repr. 1968.

Schwartz, Robert (1999) 'Rationalism vs. Empiricism', in *The MIT Encyclopedia of the Cognitive Sciences*, eds. Robert A. Wilson and Frank C. Keil, Cambridge, MA: MIT Press, pp. 703–5.

Scilla, Agostino (1996 [1670]) *La vana speculazione disingannata dal senso*, ed. Marco Segala, Florence.

Scruton, Roger (1994) *Modern Philosophy: An Introduction and Survey*, London: Sinclair-Stevenson.

(2002) *A Short History of Modern Philosophy*, 2nd rev. ed., London: Routledge.

Selle, Christian Gottlieb (1782) untitled preface, *Neue Beiträge zur Natur- und Arzeneiwissenschaft*, 1.

(1784) 'Versuch eines Beweises, daß es keine reine von der Erfahrung unabhängige Vernunftbegriffe gebe', *Berlinische Monatsschrift*, 2, pp. 565–74; trans. as 'Attempt at a proof that there are no pure concepts of reason that are independent of experience', in Sassen 2000b, pp. 193–8.

(1786–7) 'De la realité et l'idéalité des objets de nos conoissances', *Memoires de l'Académie Royale des Sciences et Belles-Lettres*, pp. 577–612 (published in 1792).

(1788) *Grundsätze der reinen Philosophie*, Berlin, repr. 1968.

Senebier, Jean (1775) *L'Art d'observer*, Geneva.

Sennert, Daniel (1618) *Epitome naturalis scientiae*, Wittenberg.

(1660) *Thirteen Books of Natural Philosophy*, London.

Sergeant, John (1696) *The Method to Science*, London.

Serjeantson, Richard (1999) 'Testimony and proof in early-modern England', *Studies in History and Philosophy of Science*, 30, pp. 196–236.

(2006) 'Proof and persuasion', in Park and Daston 2006, pp. 132–75.

(2008) '"Human understanding" and the genre of Locke's *Essay*', *Intellectual History Review*, 18, pp. 157–71.

(2014) 'Francis Bacon and the "interpretation of nature" in the late Renaissance', *Isis*, 105, pp. 681–705.

Sgarbi, Marco (2001) 'La logica di Hobbes e la tradizione aristotelica', *Lo sguardo*, 5, pp. 1–14.

(2010) 'Metaphysics in Königsberg prior to Kant', *Trans/Form/Açao* (Marília, Brazil) 33, pp. 31–64, http://dx.doi.org/10.1590/S0101-31732010000100004, archived at https://archive.ph/tYh9I.

Shand, John (1993) *Philosophy and Philosophers: An Introduction to Western Philosophy*, London: UCL Press.

Shank, J. B. (2008) *The Newton Wars and the Beginning of the French Enlightenment*, Chicago: University of Chicago Press.

Shapin, Steven (1994) *A Social History of Truth: Civility and Science in Seventeenth-Century England*, Chicago: University of Chicago Press.

Shapin, Steven and Schaffer, Simon (1985) *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, Princeton: Princeton University Press.

Shapiro, Alan E. (2004) 'Newton's "experimental philosophy"', *Early Science and Medicine*, 9, pp. 185–217.

Shapiro, Barbara (1999) *A Culture of Fact: England 1550–1720*, Ithaca: Cornell University Press.

Sharrock, Robert (1660) *The History of the Propagation & Improvement of Vegetables*, Oxford.
Simpson, William (1669) *Hydrologia Chymica*, London.
(1670) *Hydrological Essayes, or, A Vindication of Hydrologia Chymica*, London.
Sloan, Phillip R. (2006) "Natural history", in Haakonssen 2006a, 2, pp. 903–38.
Smith, Adam (1776) *An Inquiry into the Nature and Causes of the Wealth of Nations*, 2 vols., London.
(2002) *The Theory of Moral Sentiments*, ed. Knud Haakonssen, Cambridge: Cambridge University Press.
Smith, George E. (2002) 'The methodology of the *Principia*', in Cohen and Smith 2002, pp. 138–73.
Smith, Pamela H. (2009) 'Science on the move: recent trends in the history of early modern science', *Renaissance Quarterly*, 62, pp. 345–75.
Smith, Pamela H., Meyers, Amy R. W., and Cook, Harold J., eds. (2014) *Ways of Making and Knowing: The Material Culture of Empirical Knowledge*, Ann Arbor: University of Michigan Press.
Soppelsa, Maria Laura (1989) *Leibniz e Newton in Italia: Il dibattito padovano (1687–1750)*, Trieste: Lint.
Sorell, Tom (2000) *Descartes: A Very Short Introduction*, Oxford: Oxford University Press.
(2018) 'Experimental Philosophy and the history of philosophy', *British Journal for the History of Philosophy*, 26, pp. 829–49.
South, Robert (1663) *A Sermon Preached at the Cathedral of St. Paul, Novem. 9, 1662*, London.
Specht, Rainer (1979), 'Einleitung', in *Geschichte der Philosophie in Text und Darstellung*, vol. 5: *Rationalismus*, Stuttgart: Reclam, pp. 11–21.
Sperber, Peter (2017) '"There's no success like failure": on the early reception of Kant's most famous synthesis', *Rivista di storia della filosofia*, new series, 72, pp. 597–606.
Spiller, Michael R. G. (1980) *'Concerning Natural Experimental Philosophie': Meric Causabon and the Royal Society*, The Hague: Nijhoff.
Spink, Aaron (2018) 'The experimental physics of Jacques Rohault', *British Journal for the History of Philosophy*, 26, pp. 850–70.
Sprat, Thomas (1667) *The History of the Royal-Society of London for the Improving of Natural Knowledge*, London.
Starkey, George (1661) *Via ad vitam, being a short and sure Way to a Long Life, or, Helmont justified, and the Excellency of Chymicall Medicaments Vindicated*, London.
Steele, Richard and Addison, Joseph, eds. (1888 [1711–12]) *The Spectator*, London: Routledge and Sons.
Steinle, Friedrich (2016a) *Exploratory Experiments: Ampère, Faraday, and the Origins of Electrodynamics*, trans. Alex Levine, Pittsburgh: University of Pittsburgh Press.

(2016b) 'Stability and replication of experimental results: a historical perspective', in *Reducibility: Principles, Practices, and Prospects*, eds. Harald Atmanspacher and Sabine Maasen, Hoboken: Wiley, pp. 39–63.

Stewart, Dugald (1854 [1815–21]) 'Dissertation exhibiting the Progress of Metaphysical, Ethical and Political Philosophy, since the Revival of Letters in Europe', in Dugald Stewart, *Collected Works*, ed. William Hamilton, Edinburgh: Constable, 1854–8, vol. 1.

Stewart, Larry (1992) *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660–1750*, Cambridge: Cambridge University Press.

Stewart, M. A., ed. (1990) *Studies in the Philosophy of the Scottish Enlightenment*, Oxford: Clarendon Press.

Strazzoni, A. (2019) *Burchard de Volder and the Age of the Scientific Revolution*, Cham: Springer.

Stroup, A. (1990) *A Company of Scientists: Botany, Patronage, and Community at the Seventeenth-Century Parisian Academy of Sciences*, Berkeley: University of California Press.

Stubbe, Henry (1670a) *Campanella Revived: Or, An Enquiry into the History of the Royal Society, Whether the Virtuosi there do not Pursue the Projects of Campanella for the Reducing England unto Popery*, London.

(1670b) *Legends no Histories: Or, A Specimen of Some Animadversions upon The Royal Society*, London.

(1670c) *The Plus Ultra reduced to a Non Plus*. Forms part of Stubbe 1670b.

Sturdy, David, J. (1995) *Science and Social Status: The Members of the Académie des Sciences, 1666–1750*, Woodbridge: Boydell Press.

Sturm, Christoph (1676) *Collegium experimentale sive curiosum*, Nuremberg.

(1685) *Collegii experimentale sive curiosi, pars secunda*, Nuremberg.

Sulzer, Johann Georg (1759) *Kurzer Begriff aller Wißenschaften und andern Theile der Gelehrsamkeit*. 2nd ed., revised and enlarged, Leipzig: Langenheim.

Swammerdam, Jan (1681) *Ephemeri vita, or, The Natural History and Anatomy of the Ephemeron, a Fly that Lives but Five Hours*, London.

Sydenham, Thomas (1848) *The Works of Thomas Sydenham, M.D.*, 2 vols., ed. R. G. Latham, London: The Sydenham Society.

(1991) *Thomas Sydenham's* Observationes Medicae *and his 'Medical Observations'*, ed. G. G. Meynell, Folkestone: Winterdown Books.

Sylvius, Franciscus (1681) *Opera medica, hoc est, disputationum medicarum decas*, Geneva.

Sytsma, Justin (2017) 'Two origins stories for experimental philosophy', *Teorema*, 36, pp. 23–43.

Talas, Sifia (2013) 'New light on the cabinet of physics of Padua', in Bennett and Talas 2013, pp. 49–67.

Tartaglia, Niccolò (1546) *Quesiti et inventioni diverse*, Venice.

Tennemann, Wilhelm Gottlieb (1794) 'Vorrede', in David Hume, *Untersuchung über den menschlichen Verstand: Nebst einer Abhandlung über den*

philosophischen Skepticismus von Herrn Professor Reinhold, trans. Wilhelm Gottlieb Tennemann, Jena, pp. iii–xii.

(1795) 'Uebersicht des Vorzüglichsten, was für die Geschichte der Philosophie seit 1780 geleistet worden', *Philosophisches Journal einer Gesellschaft Teutscher Gelehrten*, 2, pp. 323–41. Published anonymously.

(1798–1819) *Geschichte der Philosophie*, 12 vols., Leipzig: Barth, repr. 1969–74.

(1801) 'Revision der Bearbeitung der Geschichte der Philosophie in den letzten drey Quinquennien', *Allgemeine Literatur-Zeitung. Ergänzungsblätter*, 2, cols. 25–30, 33–64, 529–49. Published anonymously.

(1816) *Grundriß der Geschichte der Philosophie: Für den akademischen Unterricht*, 2nd revised ed., Leipzig: Barth.

Tetens, Johann Nicolaus (1760) *Gedancken über einige Ursachen, warum in der Metaphysik nur wenige ausgemachte Wahrheiten sind*, Bützlow and Wismar.

(1777) *Philosophische Versuche über die menschliche Natur und ihre Entwicklung*, 2 vols., Leipzig: Weidmanns Erben und Reich, repr. 1979. Partial trans. as *Philosophical Essays on Human Nature and Its Development*, in Watkins 2009, pp. 357–91.

(1913 [1775]) *Über die allgemeine speculativische Philosophie*, in *Über die allgemeine speculativische Philosophie. Philosophische Versuche über die menschliche Natur und ihre Entwickelung*, Berlin, vol. 1 (only published), pp. 1–72.

Thomas, Janice (2009) *The Minds of the Moderns: Rationalism, Empiricism, and Philosophy of Mind*, Stocksfield: Acumen.

Tiedemann, Dieterich (1785) 'Ueber die Natur der Metaphysik: Zur Prüfung von Hrn Professor Kants Grundsätzen', *Hessische Beiträge zur Gelehrsamkeit und Kunst*, 1, pp. 113–30, http://archiv.ub.uni-marburg.de/eb/2010/0299/.

(1791–7) *Geist der spekulativen Philosophie*, 6 vols., Marburg.

Timpler, Clemens (1613) *Physicae seu Philosophiae naturalis systema methodicum in tres partes digestum*, 3 vols., Hanau.

Tittel, Gottlob August (1787) *Kantische Denkformen oder Kategorien*, Frankfurt a.M., repr. 1968; partial trans. *On Kantian Forms of Thought or Categories*, in Sassen 2000b, pp. 215–30.

Toland, John (1696) *Christianity not Mysterious*, London.

Toletus, F. (1585) *Commentaria, una cum quaestionibus, in octo libros Aristotelis de physica auscultatione: Item, in lib. Arist. de generatione et corruptione*, Cologne.

Tomeo, Leonico (1525) *Opuscula nuper in lucem aedita*, Venice.

Tonelli, Giorgio (1959) *Elementi metodologici e metafisici in Kant dal 1745 al 1768: Saggio di sociologia della conoscenza*, vol. 1 (only published), Turin: Edizioni di 'Filosofia'.

(1966) 'Die Anfänge von Kants Kritik der Kausalbeziehungen und ihre Voraussetzungen im 18. Jahrhundert', *Kant-Studien*, 57, pp. 257–69.

(1975) 'The problem of the classification of the sciences in Kant's time', *Rivista critica di storia della filosofia*, 39, pp. 243–94.

(1994 [1974]) 'Kant's Critique of Pure Reason within the tradition of modern logic', in *Kant's Critique of Pure Reason within the Tradition of Modern Logic: A Commentary on Its History*, ed. David H. Chandler, Hildesheim: Olms, pp. 1–10.

Tonelli Olivieri, Grazia (1991) 'Galen and Francis Bacon: faculties of the soul and the classification of knowledge', in *The Shapes of Knowledge from the Renaissance to the Enlightenment*, eds. Donald R. Kelley and Richard H. Popkin, Dordrecht: Kluwer, pp. 61–81.

Torlais, Jean (1964) 'La physique expérimentale', in *Enseignement et diffusion des sciences in France au XVIIIe siècle*, ed. R. Taton, Paris: Herman, pp. 619–45.

Tremigliozzi, Gaetano (1700) *Nuova staffetta da Parnasso circa gli affari della medicina*, Frankfurt a.M. (actually published in Venice).

Tunstall, James (1759) *Academica: Part the First, Containing Several Discourses on the Certainty, Distinction, and Connection of Natural and Revealed Religion*, London.

Turnbull, George (1740a) *A Treatise on Ancient Painting*, London.

(1740b) *The Principles of Moral Philosophy: An Enquiry into the Wise and Good Government of the Moral World*, London.

(2005 [1740]) *The Principles of Moral and Christian Philosophy*, vol. 1, ed. Alexander Broadie, Indianapolis: Liberty Fund.

Turner, A. J. (2004) 'Robert Plot', *Oxford Dictionary of National Biography*, https://doi.org/10.1093/ref:odnb/22385.

Turner, W. E. S. (1963) 'A notable British seventeenth century contribution to the literature of glassmaking', *Glass Technology*, 3, pp 201–13.

Tyrrell, James (1692) *A Brief Disquisition of the Law of Nature*, London.

Tyson, Edward (1680) *Phocaena, or The Anatomy of a Porpess*, London.

Übele, Wilhelm (1911) *Johann Nicolaus Tetens nach seiner Gesamtentwicklung betrachtet mit besonderer Berücksichtigung des Verhältnisses zu Kant*, Kantstudien Ergänzungshefte, 24, Berlin: Reuther & Reichard.

Van Deusen, Neil (1935) 'The place of Telesio in the history of philosophy', *Philosophical Review*, 44, pp. 417–34.

Vanzo, Alberto (2013) 'Kant on Empiricism and Rationalism', *History of Philosophy Quarterly*, 30, pp. 53–74.

(2014), 'From empirics to empiricists', *Intellectual History Review*, 24, pp. 517–38.

(2015) 'Christian Wolff and experimental philosophy', *Oxford Studies in Early Modern Philosophy*, 7, pp. 225–55.

(2016a) 'Empiricism and rationalism in nineteenth-century histories of philosophy', *Journal of the History of Ideas*, 77, pp. 253–82.

(2016b) 'Experiment and speculation in seventeenth-century Italy: the case of Geminiano Montanari', *Studies in History and Philosophy of Science*, 56, pp. 52–61.

(2017) 'Corpuscularism and experimental philosophy in Domenico Guglielmini's *Reflections* on salts', in Anstey 2017a, pp. 147–71.

(2018) 'Introduction' to *British Journal for the History of Philosophy* on 'Experimental Philosophy', 26, pp. 805–11.
(2019) 'Experimental philosophy and religion in seventeenth-century Italy', in Vanzo and Anstey 2019, pp. 204–28.
Vanzo, Alberto and Anstey, Peter R., eds. (2019) *Experiment, Speculation and Religion in Early Modern Philosophy*, New York: Routledge.
Varenius, Bernardus (1650) *Geographia generalis*, Amsterdam.
(1672) *Geographia generalis*, Cambridge.
(1681) *Geographia generalis*, 2nd ed., Cambridge.
(1712) *Geographia generalis*, Cambridge.
Vaughan, Thomas (1669) *A Brief Natural History Intermixed with Variety of Philosophical Discourses; and Observations of the Burning of Mount Ætna* London.
Vesalius, Andreas (1543) *De humani corporis fabrica*, Basel.
Vine, Angus (2010) *In Defiance of Time: Antiquarian Writing in Early Modern England*, Oxford: Oxford University Press.
Vives, Juan Luis (1531) *De disciplinis libri xx*, Antwerp; partial trans. as *On Education*, trans. F. Watson, Cambridge: Cambridge University Press, 1913.
Vleeschauwer, Herman Jean de (1934–7) *La déduction transcendentale dans l'oeuvre de Kant*, 3 vols., Antwerp: De Sikkel, repr. 1976.
Voltaire (1734) *Lettres philosophiques*, Amsterdam.
(1765) 'Histoire', in *Encyclopédie*, vol. 8, eds. Denis Diderot and Jean Le Rond d'Alembert, Paris, 1751–72, pp. 220–5.
(1877–85) *Oeuvres complètes de Voltaire*, 52 vols., Paris: Garnier.
(1994 [1733]) *Letters Concerning the English Nation*, ed. Nicholas Cronk, Oxford: Oxford University Press.
Walch, Johann Georg (1721) 'Historia logicae', in *Parerga academica ex historiarum atque antiquitatum monimentis collecta*, Leipzig, pp. 453–848.
Waldow, Anik (2010) 'Empiricism and its roots in the ancient medical tradition', in Wolfe and Gal 2010, pp. 287–308.
Waller, Richard, trans. (1684) *Essayes of Natural Experiments Made in the Academie del cimento*, London.
Wallis, John (1675) *A Discourse of Gravity and Gravitation, Grounded on Experimental Observations*, London.
(1678) *A Defence of the Royal Society*, London.
Walsh, Kirsten (2014) 'Newton's epistemic triad', PhD dissertation, University of Otago.
(2017) 'Principles in Newton's natural philosophy', in Anstey 2017a, pp. 194–223.
Walsh, Kirsten and Currie, Adrian (2015) 'Caricatures, myths, and white lies', *Metaphilosophy*, 46, pp. 414–35.

Walsh, W. H. (1981) 'Kant and Empiricism', in *200 Jahre Kritik der reinen Vernunft*, eds. Joachim Kopper and Wolfgang Marx, Hildesheim: Gerstenberg, pp. 384–420.
Warntz, William (1989) 'Newton, the Newtonians and the *Geographia Generalis Varenii*', *Annals of the Association of American Geographers*, 79, pp. 165–91.
Watkins, Eric (2005) *Kant and the Metaphysics of Causality*, Cambridge: Cambridge University Press.
Watkins, Eric, ed. and trans. (2009) *Kant's Critique of Pure Reason: Background Source Materials*, Cambridge: Cambridge University Press.
Watson, Richard A. (1993) 'Shadow history in philosophy', *Journal of the History of Philosophy*, 31, pp. 95–109.
Watts, Isaac (1733) *Philosophical Essays on Various Subjects*, London.
Waxman, Wayne (2005) *Kant and the Empiricists: Understanding Understanding*, Oxford: Oxford University Press.
Webster, Charles (1969) 'Henry More and Descartes: some new sources', *British Journal for the History of Science*, 4, pp. 359–77.
(2002) *The Great Instauration: Science, Medicine and Reform 1626–1660*, Berlin: Peter Lang.
Webster, John (1654) Academiarum Examen*, or the Examination of Academies*, London.
Weisheipl, James A. (1965) 'Classification of sciences in medieval thought', *Mediaeval Studies*, 27, pp. 54–90.
Westfall, R. S. (1980) *Never at Rest: A Biography of Isaac Newton*, Cambridge: Cambridge University Press.
Wezel, Johann Carl (1784) *Versuch über die Kenntniß des Menschen*, vol. 1, Leipzig.
Whiston, William (1696) *A New Theory of the Earth*, London.
(1698) *A Vindication of the New Theory of the Earth from the Exceptions of Mr. Keill and Others with an Historical Preface of the Occasions of the Discoveries therein contain'd, and some Corrections and Additions*, London.
(1717) *Astronomical Principles of Religion, Natural and Revealed*, London.
(1753) *Memoirs of the Life and Writings of William Whiston*, 2nd ed., London.
Wigelsworth, Jeffrey R. (2010) *Selling Science in the Age of Newton: Advertising and the Commoditization of Knowledge*, Farnham: Ashgate.
Wilkins, John (1648) *Mathematicall Magick: Or, The Wonders that May be Performed by Mechanicall Geometry*, London.
(1675) *Of the Principles and Duties of Natural Religion*, London.
Will, Georg Andreas (1788) *Vorlesungen über die Kantische Philosophie*, Altdorf, repr. 1968.
Williams, Bernard (1978) *Descartes: The Project of Pure Enquiry*, London: Penguin.
Willughby, Francis (1686) *Historia piscium*, Oxford.
Wilson, Catherine (1997) 'Motion, sensation, and the infinite: the lasting impression of Hobbes on Leibniz', *British Journal for the History of Philosophy*, 5, pp. 339–51.

Wolfe, Charles (2010) 'Empiricist heresies in early modern medical thought', in Wolfe and Gal 2010a, pp. 333–44.

Wolfe, Charles and Gal, Ofer, eds. (2010a) *The Body as Object and Instrument of Knowledge: Embodied Empiricism in Early Modern Science*, Dordrecht: Springer.

Wolfe, Charles and Gal, Ofer (2010b) 'Introduction', in Wolfe and Gal 2010a, pp. 1–5.

Wolff, Christian (1725) *Vernünfftige Gedancken von den Würckungen der Natur*, 2nd ed., Halle: Renger.

(1727–9) *Allerhand nützliche Versuche, dadurch zu genauer Erkänntnis der Natur und Kunst der Weg gebähnet wird*, 3 vols., Halle: Renger, repr. in Wolff 1962–, sect. 1, vol. 20.

(1729a) 'De differentia intellectus systematici & non systematici', in Wolff 1729d, pp. 107–54.

(1729b) 'De Hypothesibus philosophicis', in Wolff 1729d, pp. 177–230.

(1729c) 'De notionibus directricibus & genuino usu philosophiae primae', in Wolff 1729d, pp. 310–50.

(1729d) *Horae subsecivae marburgenses anni MDCCXXIX*, Frankfurt a.M.: Renger, repr. in Wolff 1962–, sect. 1, vol. 34.1.

(1733) *Ausführliche Nachricht von seinen eigenen Schrifften, die er in deutscher Sprache . . . heraus gegeben*, 2nd enlarged ed., Frankfurt a.M., repr. in Wolff 1962–, sect. 2, vol. 9.

(1735a) 'De Experientia morali', in Wolff 1735c, pp. 681–719, repr. in Wolff 1962– , sect. 1, vol. 34.3.

(1735b) 'De Influxu philosophiae Autoris in Facultates superiores', in Wolff 1735c, pp. 1–106, repr. in Wolff 1962– , sect. 1, vol. 34.3.

(1735c) *Horae subsecivae marburgenses anni MDCCXXXI*, Frankfurt a.M., repr. in Wolff 1962–, sect. 1, vol. 34.3.

(1735d) *Ratio praelectionum*, 2nd enlarged ed., Halle, repr. in Wolff 1962–, sect. 2, vol. 36.

(1736) *Philosophia prima sive ontologia*, Frankfurt a.M, repr. in Wolff 1962–, sect. 1, vol. 3.

(1736–40) *Gesammelte kleine philosophische Schrifften*, 6 vols., Halle, repr. in Wolff 1962–, sect. 3, vol. 21.

(1737a) *Cosmologia generalis*, Frankfurt a.M., repr. in Wolff 1962–, sect. 2, vol. 4.

(1737b), 'Von dem Nuzen der Erkenntnis der Natur, in der Erkenntnis GOttes [*sic*] und der Herrschaft über die Creaturen', in Wolff 1736–40, vol. 3, pp. 317–32, repr. in Wolff 1962–, sect. 3, vol. 21.

(1737c), 'Von den willkührlichen Säzen in der Weltweißheit, oder den philosophischen Meinungen', in Wolff 1736–40, vol. 2, pp. 226–309, repr. in Wolff 1962–, sect. 3, vol. 21.2.

(1738) *Psychologia empirica*, revised ed., Halle, repr. in Wolff 1962–, sect. 1, vol. 5.

(1740a) 'Discursus praeliminaris de philosophia in genere', in Wolff 1740b, pp. 1–104, repr. in Wolff 1962–, sect. 2, vol. 1, trans. Richard J. Blackwell as *Preliminary Discourse on Philosophy in General* (Indianapolis: Bobbs-Merrill, 1963). The translations used in the text are ours, not Blackwell's.

(1740b) *Philosophia rationalis sive Logica*, 3rd revised ed., Frankfurt a.M., pp. 1–104, repr. in Wolff 1962–, sect. 2, vol. 1.

(1741) *Elementa matheseos universae*, Halle, repr. in Wolff 1962–, sect. 2, vol. 33.

(1751) *Vernünftige Gedancken von GOTT, der Welt und der Seele des Menschen*, Halle, repr. in Wolff 1962–, sect. 1, vol. 5.

(1755), 'Praefatio Physicae Electivae Jo. Christoph. Sturmii Tomi II', in *Meletemata mathematico-philosophica*, Halle, sect. 3, pp. 140–7, repr. in Wolff 1962–, sect. 2, vol. 35.

(1962 [1754]) *Vernünftige Gedancken von den Kräfften des menschlichen Verstandes und ihrem richtigen Gebrauche in Erkänntniß der Wahrheit*, ed. Hans Werner Arndt, Hildesheim: Olms = Wolff 1962–, sect. 1, vol. 1.

(1962–) *Gesammelte Werke*, Hildesheim: Olms.

Wolterstorff, Nicholas P. (1999) 'Empiricism', in *The Cambridge Dictionary of Philosophy*, ed. Robert Audi, 2nd ed., Cambridge: Cambridge University Press, pp. 262–3.

Wood, Anthony (1692) *Athenae Oxonienses*, vol. 2, London.

Wood, Paul B. (1980) 'Methodology and apologetics: Thomas Sprat's *History of the Royal Society*', *British Journal for the History of Science*, 13, pp. 1–26.

(1990) 'Science and the pursuit of virtue in the Aberdeen Enlightenment', in M. A. Stewart 1990, pp. 127–49.

(1994) 'Hume, Reid and the science of the mind', in *Hume and Hume's Connexions*, eds. M. A. Stewart and John P. Wright, Edinburgh: Edinburgh University Press, pp. 119–39.

Woodward, John (1695) *An Essay Toward a Natural History of the Earth*, London. 3rd ed. 1723.

(1696) *Brief Instructions for Making Observations in All Parts of the World*, London.

(1735) *Geographie physique, ou essay sur l'histoire naturelle de la terre*, Paris.

Woolhouse, Roger (1988) *The Empiricists*, Oxford: Oxford University Press.

Wootton, David (2015) *The Invention of Science: A New History of the Scientific Revolution*, London: Allen Lane.

Worrall, John (2000) 'The scope, limits, and distinctiveness of the method of "Deduction from the phenomena": some lessons from Newton's "Demonstrations" in Optics', *British Journal for the Philosophy of Science*, 51, pp. 45–80.

Worster, Benjamin (1722) *A Compendious and Methodical Account of the Principles of Natural Philosophy*, London.

Wotton, William (1694) *Reflections Upon Ancient and Modern Learning*, London.

Wren, Christopher (1750) *Parentalia*, London.

Wren, Matthew (1659) *Monarchy Asserted*, Oxford.

Yeo, Richard (2003) 'Classifying the sciences', in *The Cambridge History of Science*: vol. 4, *Eighteenth Century Science*, ed. Roy Porter, Cambridge: Cambridge University Press, pp. 241–66.

Yolton, John W. (1956) *John Locke and the Way of Ideas*, Oxford: Oxford University Press.

Young, Mark T. (2017a) 'Enchanting automata: Wilkins and the wonder of workmanship', *Intellectual History Review*, 27, pp. 453–71.

(2017b) 'Nature as spectacle: experience and empiricism in early modern experimental practice', *Centaurus*, 59, pp. 72–96.

Zabarella, Jacopo (1597) 'De natura logicae', in *Opera Logica*, 3rd ed., Cologne, cols. 1–102, repr. 1966.

Zallinger, J. (1773) *Interpretatio naturae, seu philosophia Newtoniana methodo exposita et academicis usibus adcommodata*, Augsburg.

Zalta, Edward N., ed. (1997–) *The Stanford Encyclopedia of Philosophy*, http://plato.stanford.edu/.

Zammito, John H. (2002) *Kant, Herder and the Birth of Anthropology*, Chicago: University of Chicago Press.

Zart, Gustav (1881) *Einfluss der englischen Philosophen seit Bacon auf die deutsche Philosophie des 18. Jahrhunderts*, Berlin: Dümmler.

Zuckert, Rachel (2007) *Kant on Beauty and Biology: An Interpretation of the Critique of Judgment*, Cambridge: Cambridge University Press.

INDEX

Abel, Jakob Friedrich, 226, 227, 231
Abercrombie, David, 48
Académie des Sciences, 63, 64, 75, 76, 149–51, 153, 156–57, 159
Accademia degli Aletofili (Verona), 63
Accademia dei Fisiocritici (Sienna), 63, 174
Accademia del Cimento, 4, 62–3
  Saggi, 4, 62, 75
Acosta, José de, 78
Addison, Joseph, 141, 222
aesthetics, 1, 20, 226, 235, 247, 249, 250, 252, 280, 286. *See* Kant, Immanuel
Agricola, Georgius, 34–5
agriculture, 34, 76, 98
Agrippa, Cornelius, 32
Aldrovandi, Ulisse, 78
Alsted, Johann Heinrich, 277
Altdorf Academy, 205
anatomy, 23–4, 80, 115–16, 119, 218–19
antiquities, study of, 40, 145, 218, 219
anti-system sentiment. *See* France
archemastrie. *See* Dee, John
Aristotelianism, 30, 152, 272, 277, 294
  as speculative philosophy, 20, 294
  natural philosophy, 9, 23, 69–70, 83, 137
  theory of forms and qualities, 70, 83
Aristotelians, 29, 33, 71, 128, 137
  as speculative philosophers, 69
Aristotle, 22–3, 28, 30, 39, 42, 48–9, 51, 56, 57, 62, 65, 69, 244–5, 270, 277, 290
  and natural history, 78
  divisions of knowledge, 7, 21, 25–7, 37
  Posterior Analytics, 6, 9
  practical intellect and speculative intellect, 25
  syllogistic, 9, 56, 214
Ashe, Sir George, 55
astronomy, 22, 23, 29, 106, 119, 121, 124, 143, 164, 208, 213, 218–19
Aubrey, John, 46, 88, 96, 98
Austen, Ralph, 41, 81, 82, 93–4, 96, 98
Averroes, 36
Avicenna, 30
Ayers, Michael, 292

Bacon, Francis, 2, 8, 10, 20, 21, 23, 27, 29, 31, 32, 37, 39–42, 48, 72, 73, 117, 141, 149–54, 158, 159, 170–4, 180, 183, 197, 206, 210, 229, 230, 233, 248, 253–4, 259, 272–80, 283, 287, 288
  Advancement of Learning, 2, 33, 81, 171
  classification of natural philosophy, 34–6
  criticisms of contemporary natural history, 78, 80, 163
  De augmentis scientiarum, 27, 33, 34, 35, 39, 81, 154, 162, 166–7, 168, 180
  Historia naturalis, 89
  History of Life and Death, 36, 81, 101, 161
  History of Winds, 36, 81, 162
  idols, 41
  intermediate causes, 50, 52
  natural history, 12–13, 33, 34, 36, 39, 75–108, 112, 158–69

Bacon, Francis (cont.)
Novum organum, 33, 36, 41, 50, 79, 81, 83, 90, 92, 95, 152, 161, 163, 166, 167, 168, 171, 189, 230
on induction, 49, 63, 81, 89, 151, 174
on intellectual faculties, 35, 38
on magic, 33
on mathematics, 36
on mechanics, 34
Parasceve, 34, 83, 84, 89, 90, 97, 98, 161, 166
Solomon's house, 53
Sylva Sylvarum, 36, 79, 81, 94, 97, 100, 101, 105
tripartite division of knowledge, 35–6
Bacon, Roger, 30, 31
Baconian natural history. *See* natural history
Baglivi, Georgio, 5, 61, 104
Baldi, Bernadino, 34
Barbeyrac, Jean, 180, 199
Barrow, Isaac, 6, 102, 142
Bartoli, Daniello, 5, 40, 62
Bate, Julius, 73, 173
Bathurst, Ralph, 119
Baumeister, Friedrich Christian, 204
Baumgarten, Alexander Gottlieb, 247, 250
Baxter, Richard, 38, 192
Bayle, Pierre, 275, 276, 277, 278
Beale, John, 101
Beattie, James, 178, 180, 228, 229, 231, 248, 277
Beaumont, John, 98, 103
Bennett, Jonathan, 292
Bentham, Edward, 179, 180
Bentley, Richard, 68, 135, 138, 145
Bérigard, Claude Guillermet de, 276, 277
Berkeley, George, 55, 234, 236, 248, 252–4, 275, 276, 278, 279, 291–2
idealism, 255, 280–2
Berlin Academy, 5, 71, 203–4, 223, 230, 261, 286
classes of, 217–19, 294
lack of antagonism between experimental and speculative philosophy, 220–2
restructured in the 1740s, 217
Bernard, Jean-François, 102
Biener, Zvi, 292–8
Bilfinger, Georg Bernhard, 280
Birch, Thomas, 99
Blackmore, Sir Richard, 19, 42
Blome, Richard, 87
Blount, Sir Thomas, 107–8
Blundeville, Thomas, 6, 29
Boate, Gerard, 87
Bodenmann, Siegfried, 295
Boerhaave, Herman, 173, 295
Böhme, Jacob, 276
Bohun, Ralph, 81, 98
Bonnet, Charles, 276
botany, 84, 212, 218, 219
Boullier, David Renaud, 173
Bowen, Margarita, 87
Boyle, Charles, 46
Boyle, Robert, 2, 4, 8, 10, 11, 30, 44–55, 63–73, 79, 81–108, 120, 128, 132, 138, 150, 151, 159, 161, 173, 185, 192, 194, 197, 210, 216, 229, 248, 273, 275, 277, 285, 288, 294, 298
'De imperfectione Historiae Naturalis', 81–2
'Designe about natural history', 88–91, 98, 100
'Essay of nitre', 73
'General heads', 76, 80, 84–6, 101–3, 142
'Of Naturall Philosophie', 50, 52, 67
'Of the Study of the Book of Nature', 67
'Of usefulnes of speculative & experimental philosophy to one another', 52
'The Order of my Severall Treatises', 88
against systems, 51, 181
air-pump experiments, 11, 21, 44–5, 66, 194
and fallibilism, 51
and natural history, 13, 80–91, 96–107, 111–12, 141–2, 162, 210
and the experimental/speculative distinction, 12, 42, 113, 210–11, 294
and the *novatores*, 23

as father of experimental philosophy, 50, 171
Boyle Lectures, 68, 193
Boyle's Law, 44
Certain Physiological Essays, 19, 47, 50, 64, 97
Christian Virtuoso, I, 4, 68, 216, 275
Christian Virtuoso, II, 68
Cold, 13, 24, 83, 91, 96, 98–101
Colours, 64, 90, 94, 99, 111, 112
Defence against Linus, 95, 205
Experimenta et Observationes Physicae, 94
Flame and Air, 152
Forms and Qualities, 64, 83, 88, 151
General History of the Air, 13, 80, 83, 100, 101, 104, 105
Human Blood, 13, 83, 96, 105
intermediate causes, 44, 52
medical writings, 60
Mineral Waters, 13, 83, 90–1, 101
on animal respiration, 45
on chymistry as natural history, 84
Saltness of the Sea, 162
Sceptical Chymist, 64
Seraphic Love, 40, 46–7
Spring of the Air, 2, 11, 40, 45–7, 64, 66, 83, 84, 111, 112, 142, 205
Usefulness, 2, 46, 47, 52, 53, 60, 64, 151
Varenius, 84–6
Bradley, James, 120, 124–6, 188
nutation, 124, 188
Brastberger, Gebhard Ulrich, 261
Briot, Pierre, 64
Brown, Robert, 288
Brownian motion, 288
Browne, John, 103
Brucker, Jakob, 262, 269, 270, 272, 275, 277
Bruno, Giordano, 270
Budde, Johann Franz, 277
Buffon, Comte de, 169, 175, 190, 287
'Premier discours', 159–62
and mathematics, 164–5
and travel literature, 161
Baconian natural history, 158–66
Histoire naturelle, 158, 160–2, 167, 190
on hypotheses, 165–6
Buhle, Johann Gottlieb, 14, 203, 223, 224, 259, 268, 274
Burgersdijck, Franco, 27, 29
Burke, Edmund, 247, 249
Burnet, Thomas, 127, 277
Büsch, Johann Georg, 230
Butler, Joseph, 189, 191–3, 196, 197
Analogy of Religion, 191, 193

Cabeo, Niccolò, 23, 40
Calvin, John, 40
Camden, William, 87
Campanella, Tommaso, 27, 33, 40, 51, 69
Cardano, Girolamo, 22
Cartesianism, 64–6, 73, 122, 134, 152, 254
as speculative philosophy, 20, 41, 48, 173, 174, 194, 279, 294
matter, 11, 65, 194
natural philosophy, 9, 20
speculative cosmologies, 70
vortex theory, 70, 115, 128, 145, 173, 190, 206
Carus, Friedrich August, 259
Casaubon, Meric, 5, 57, 73
casuistry, 189
Cavendish, Margaret, 5, 54, 57, 69, 73, 128, 294
criticisms of experimental philosophy, 57–9
Observations, 54, 57, 58, 64, 69
Cesalpino, Andrea, 78
Chamberlayne, Peter, 67
Chambers, Ephraim, 104, 126–7, 139, 286
Chapelain, Jean, 63, 64, 76, 151
Charles II, 55
Charleton, Walter, 79, 98, 99, 277
chemistry, 84, 106, 132, 162, 168, 175, 218–19
Cherbury, Herbert, Baron of, 275, 276, 279
Cheyne, George, 195
Philosophical Principles of Natural Religion, 67, 68, 192
Childrey, Joshua, 87, 98, 150

chymical physicians, 20, 60–1, 69
chymistry. *See* chemistry
Clarke, Samuel, 133, 143–5, 192–3, 248, 275, 276
Clarke, Timothy, 43, 60, 99
Clarke, William, 79, 98
Clerke, Gilbert, 66
Clulee, Nicholas, 31
cohesion, 197
Colbatch, John, 61
Colbert, Jean-Baptiste, 76, 150, 151
Coley, Noel, 91
Collège de Montaigu, 153
Collège de Navarre, 155, 156, 286
College of Physicians, 60
Collier, Arthur, 276, 278
Colwall, Daniel, 99
Comenius, John Amos, 277
comets, 41, 76, 122, 131, 167
Condillac, Etienne Bonnot de, 151, 157–8, 167, 170, 172, 229, 259, 276, 296
Condorcet, Nicolas de Caritat, Marquis de, 178
Conimbricenses, 29, 32
Conring, Herman, 174
Conti, Antonio, 9, 138, 140, 174
Copernicus, Nicolaus, 23, 273
Copleston, Frederick, 14
Cordemoy, Gérauld de, 64
cosmology, 128, 207, 212, 214, 215
Cotes, Roger, 120, 139, 145, 222, 297
  and Leibniz's criticisms of Newton, 134–8, 145, 155
  on experimental philosophy, 123–5
  Plumian Chair of Astronomy and Experimental Philosophy, 5, 116, 155
  Preface to *Principia*, 134–8
Cowley, Abraham, 53
Coxe, Daniel, 60
Crewe, Nathaniel (3rd Baron Crew), 125
Crivelli, Giovanni, 174
Croone, William, 97, 98, 100
Crusius, Christian Adolf, 205, 246, 247, 249, 279
Cudworth, Ralph, 272, 276, 277, 283
Cumberland, Richard, 178, 181–5, 192, 193
  on laws of nature, 193–6
Currie, Adrian, 288
Cusanus, Nicolaus, 31

Dagoumer, Guillaume, 153
D'Alembert, Jean Le Rond, 6, 20, 38, 50, 166, 219, 222, 223, 248, 276, 278, 295
  'Preliminary Discourse' and experimental philosophy, 169–73
  against systems, 157, 172
  on Descartes, 173–5
D'Holbach, Paul-Henri Thiry, Baron de, 276
Daston, Lorainne, 24
De Bosses, Bartholomew, 134
de Boyer, Jean-Baptiste (Marquis d'Argens), 175
de le Boë, Franciscus (Sylvius), 41
de Villemandy, Pierre, 276
de Volder, Buchard, 66, 70
Dee, John, 30–1, 40
Degérando, Joseph-Marie, 259
Della Porta, Giambattista, 32–3
Democritus, 50
Denstonius, Arnoldus Bachimius, 40
Dent, Arthur, 41
Denyse, Jean, 153
Derham, William, 68, 205
Desaguliers, John Theophilus, 67, 116–20, 125, 149, 154, 159, 192, 221
  on experimental philosophy, 121–3
Descartes, René, 48, 49, 58, 69, 122, 128, 134, 145, 195, 206, 234, 236, 248, 253, 259, 270, 272–83, 290, 291
  as an experimental philosopher, 9, 174
  as speculative philosopher, 70, 137, 157
  cogito, 254
  conservation of motion, 194
  critic of theory of forms, 70
  extension as primary attribute of matter, 11
  on a priori knowledge of essences, 49

on cause of respiration, 45
on natural history, 75
rehabilitation of, 173
theory of comets, 41
Deslandes, André-François, 154, 157, 175, 185, 270
and natural history, 154
Deusing, Anton, 29, 66
Di Capua, Leonardo, 62
Diderot, Denis, 20, 169, 175, 185, 276, 278, 286
and Bacon, 166–9
and the experimental/speculative distinction, 20–1
on natural history, 166–9
Pensées, 167
Digby, Kenelm, 112
Dioscorides, 12, 78
Donne, John, 47
Drury, John, 2
Du Châtelet, Emilie, 166, 174, 295
Du Clos, Samuel Cottereau, 64
Du Hamel, Jean-Baptiste, 4, 40, 64, 94, 95, 151–2
Dublin Philosophical Society, 55, 92
Ducheyne, Steffen, 114
Duncan, James, 116
Dunton, John, 19, 159, 179

Earth, shape of, 122
Eberhard, Johann August, 204, 255, 260, 262–4
Edwards, Jonathan, 196
Einstein, Albert, 288
Elizabeth I, 35, 39
empirical psychology, 204, 212, 222–7, 229, 231, 233
empiricism, 3, 14, 233, 234–57, 258–68, 272–84, 288, 289
as historiographical category, 14–15, 203, 234, 255, 258–9, 262, 272, 282–3, 288–98
Encyclopédie, 166–72, 175, 220–1
'Preliminary Discourse', 157, 224
scheme of knowledge, 220
Epicureanism, 69, 249, 272
as speculative philosophy, 20
Epicurus, 69, 245, 251
essences, 8–9, 12, 48–9, 130, 153
ethics, 1, 3, 4, 14, 19, 20, 25, 27, 29, 37, 39, 176–99, 203, 207, 209, 213, 218–19, 224, 226, 227, 235, 240, 241, 247–53, 262–5, 268, 273, 274, 277, 282, 288, 292
Euclid, 30
Euclidean geometry, 13, 198
Euler, Leonard, 219
Evelyn, John, 84, 98, 99
experiment, 227. *See* observation and experiment, philosophy of experiment
unreliability of, 56
unsuccessful, 95, 96
experimental philosophy, 1–15, 43–74, 285–98
and medicine, 1, 13, 21–3, 43, 60–2, 84, 107, 175, 203, 286, 291
and religion, 13, 43, 67–9, 107, 118, 191–3, 195
antagonism towards speculative philosophy, 11, 41, 71, 156, 171, 175, 178–9, 181, 183, 220, 285
anti-system sentiment, 181
as actors' category, 290
conditions for being an experimental philosopher, 70–3
early opposition to, 56–9, 73, 128, 152, 294
movement, 1–5, 7–8, 14, 43–5, 47, 54, 72–4, 108, 203, 234, 285–6, 287, 291, 294
teaching of, 5, 111, 115–27, 139, 153–6, 286
two-stage method, 6, 62, 107, 150, 156, 176, 186, 189, 211
experimental/speculative distinction, 6–8, 14–15, 19–42, 59, 68, 69, 71, 112, 113, 125, 128, 139, 151, 169–73, 178–81, 197–8, 203, 217–22, 233, 279, 286, 288, 292–8

Fabri, Honoré, 64, 277
faculty psychology, 38, 166
Feder, Johann Georg Heinrich, 5, 21, 204, 231–2, 233, 243, 254, 260–3
Feingold, Mordechai, 46, 106
Ferguson, Adam, 180, 189

Fichte, Johann Gottlieb, 269
Ficino, Marsilio, 32, 272
Fischer, Kuno, 254, 258–9, 274
Flögel, Carl Friedrich, 231
Fludd, Robert, 277
Folkes, Martin, 141
Fonseca, Pedro da, 36
Fontenelle, Bernard Le Bovier, 150–1, 153, 156, 173
Formey, Henri Samuel, 218–21, 223
France, 1, 13, 14, 41, 48, 63–4, 66, 70, 72, 149–75, 177, 221, 222, 288, 298
  Parisian salons, 63
Frederick the Great, 175, 217–222
Freedman, Joseph S., 26
Freind, John, 132–3, 136, 138, 144
Fréret, Nicolas, 156–7
Fries, Jakob Friedrich, 233
Fuchs, Leonhart, 78

Gadroys, Claude, 64
Gale, Theophilus, 277
Galenists, 60
  on cause of respiration, 45
Galileo Galilei, 39, 41, 48, 159, 174, 194, 211, 273, 286
  and experiment, 73
Garrett, Don, 292
Garve, Christian, 233, 253–4
  review of Kant's first *Critique*, 261
Gassendi, Pierre, 40, 48, 49, 63, 248, 272, 275, 276, 277–80, 283
Gataker, Thomas, 277
geodesics, 29, 88
geography, 84–8, 142–3. *See also* natural history
geology, 84, 105, 212
geometry, 114, 122, 128, 143, 213, 218, 246. *See* Euclidean geometry
Gerard, Alexander, 223
Gessner, Conrad, 78
Geulincx, Arnold, 276
Gilbert, Sir Humphrey, 35
Gilbert, William, 35, 39, 40, 48, 262
Gimma, Giacinto, 174
Glanvill, Joseph, 9, 57, 68, 72, 73, 174, 276, 297
Glass, David, 288
Goddard, Jonathan, 60
Goethe, Johann Wolfgang Von, 226
Golden Rule, 198
Gómez, Juan, 287
Gorman, John, 116, 119
Graunt, John, 81, 94, 98, 101
Gravesande, Willem 's, 148, 149, 154, 173, 210, 221, 295
gravity, 55, 111, 130, 187, 209, 296
  as an occult quality, 132–40
Green, T. H., 259
Greene, Robert, 120
Grew, Nehemiah, 84, 98
  Experiments in Consort of Luctation, 95, 100, 150
Gröning, Johann, 129
Grosseteste, Robert, 30
Grotius, Hugo, 277
Grün, Johann, 29
Guglielmini, Domenico, 63

Hale, Matthew, 38
Hales, Stephen, 158–9
Hall, Ned, 288
Halley, Edmund, 81, 98, 106, 107, 124, 162, 173
Hamann, Johann Georg, 227, 263
Harris, John, 79, 104, 119, 132–3
Harrison, Peter, 40
Hartlib, Samuel, 75, 93, 96, 97
  'Ephemerides', 2, 40, 86
Hartsoeker, Nicolaas, 134, 136, 138–9
Harvey, Gideon, 38
Harvey, William, 24, 39, 41
Hauksbee, Francis, 121
Hegel, Georg Wilhelm Friedrich, 232, 266, 269, 281
Heineccius, Johann Gottlieb, 213
Helmont, Joan Baptiste van, 69, 277
Helvétius, Claude, 176, 248
Henshaw, Thomas, 98, 100
Herbert, Edward, 1st Baron of Cherbury, 275, 276, 279
Herz, Marcus, 204
Higgins, Bryan, 290
Highmore, Nathaniel, 45
Hine, Ellen, 296
Hirnhaim, Hieronymus, 276, 277

Hißmann, Michael, 226, 231
Hobbes, Thomas, 4, 21, 29, 58, 66, 69, 248, 274–83
Hogelande, Cornelius van, 41
Home, Henry (Lord Kames), 183, 190, 222, 228, 229
Hooke, Robert, 8, 10, 11, 44, 45, 53, 58, 70, 81, 84, 87, 92–101, 105–8, 113, 161, 185, 210–11, 288
  'General scheme', 11, 81, 83, 89–90, 93
  'Things requisite', 81, 89, 96
  A Discourse of Earthquakes, 105
  and natural history, 211
  and the experimental/speculative distinction, 12
  Micrographia, 54, 58, 64, 95, 112, 205, 287
  philosophical algebra, 89
  theory of colours, 114
Hooper, William, 176
Hoquet, Thierry, 163–4
Hornsby, Thomas, 120, 125
Hoskins, John, 97
Huet, Pierre Daniel, 64, 276, 277
Hume, David, 4, 14, 20, 177–8, 180, 189, 198, 220, 223, 229, 233, 234, 236, 245–7, 252–5, 262–7, 274, 276, 279–83, 291–2, 298
  and scepticism, 245–6, 254, 255, 264, 266, 267, 280
  association of ideas, 186–7
  on hypotheses, 183
  philosophy of experiment, 185–9
  Treatise, 20, 177, 183–8, 197, 266, 269
Hutcheson, Francis, 195–7, 198, 222, 246, 247
Huygens, Christiaan, 64, 66, 70, 73, 75–6, 102, 129, 150, 194, 195, 211, 277
hydrostatics, 6, 119–25
hypotheses, 7, 9, 10, 11, 19, 20, 24, 42, 52–5, 64, 67, 71, 74–7, 111–15, 124, 125–6, 133, 136–44, 154, 157, 159, 162–73, 174, 179–86, 193, 204, 206–12, 217, 221, 229, 288–9, 293–7

Immodest empiricism, 238–42, 247–8
induction, 19, 38, 49, 63, 81, 89, 123, 137, 139, 151–2, 174, 194, 298
innatism, 4, 38, 244–5, 250, 251, 262, 264–6, 275, 281, 289–90, 294–5
intermediate causes, 44, 50, 52
introspection, 184, 186, 188, 216, 225, 227–8, 254
Isham, Sir Justinian, 50
Italy
  and uptake of experimental philosophy, 1, 5, 13, 62–3, 73, 286–7
  scientific academies, 4, 9, 62, 63, 75, 174

Jacobi, Friedrich Heinrich, 259, 268
Jalobeanu, Dana, 112
James, William, 259
Johnson, Dr Samuel, 262
Johnson, Samuel, 180
Johnston, John, 21, 36, 37, 39, 75
Jones, Richard, 46
Jones, William, 134
Jungius, Joachim, 49
Jurin, James, 141–7
jurisprudence, 189

Kant, Immanuel, 14, 21, 204, 227, 230, 232, 297
  aesthetics, 247, 249, 250–2
  and history of philosophy, 237–8, 242–6, 248, 249, 254–7
  and the classificatory bias, 236–7, 246–9
  and the epistemological bias, 235–7, 252–3, 256
  and the Kantian bias, 235–7, 249–52, 256
  antinomies, 236–41, 246–9
  first *Critique*, 205, 227, 231, 233, 234, 238–66
  first to contrast the terms 'empiricism' and 'rationalism', 234
  immodest empiricism, 239
  lectures on metaphysics, 251
  modest empiricism, 238, 240–1, 248
  moral philosophy of, 240–1, 246–7, 249, 253
  noologism, 234, 241–3, 247–8, 250

Kant, Immanuel (cont.)
on empiricism, 3, 14, 203, 233, 234–55, 256, 259–63
on Leibniz's rationalism, 247–9, 253, 255
on Locke's empiricism, 245–7, 249, 252, 253, 255
on mysticism, 243–5, 251, 255, 261
on scepticism, 245, 249, 254–7
second *Critique*, 234, 246, 249
synthetic a priori judgements, 4, 238, 241–2, 246, 250–3, 263
third *Critique*, 234, 247, 249
Kate, Lambert ten, 67, 149, 192
Keckermann, Bartholomäus, 29
Keill, James, 144–5
Keill, John, 11, 59, 69, 143, 173, 175
as lecturer, 116, 119–22, 124
critic of the vortex theory, 70, 128
on attractive forces between particles, 127–33
on gravity as an occult quality, 131, 132, 137
theory of qualities, 128
Kepler, Johannes, 273
Kessler, Eckhard, 22
King, William, 91, 276
Kircher, Athanasius, 40
Knutzen, Martin, 230
Krug, Wilhelm Traugott, 274
Krüger, Johann Gottlob, 224
Kuehn, Manfred, 223

La Forge, Louis de, 64
La Grange, Jean Baptiste de, 64
La Mettrie, Julien Offrey de, 174, 248, 276
Lambert, Johann Heinrich, 213, 223
Lamy, Bernard, 64
Lana Terzi, Francesco, 62
law of non-contradiction, 215
law of refraction, 194
laws of motion, 35, 119, 121, 125, 137, 192, 194, 196–7, 211, 219, 222
Le Monnier, Louis Guillaume, 222
Leeuwenhoek, Antonie van, 102
Leibniz, G. W., 93, 105, 131, 133, 173, 174, 212, 217, 222, 230, 234–6, 244, 245, 246, 247–59, 263–8, 274–83, 292, 297
dispute with Newton, 134–41
monadology, 249, 273
New Essays, 96, 235, 265, 266, 281
Leibniz–Clarke correspondence, 11, 192–3
Leigh, Charles, 103
Lémery, Nicolas, 120
Leucippus, 69
Lhuyd, Edward, 103
Linnaeus, Carl (von Linné), 12
Linus, Franciscus, 66, 95, 112
Lister, Martin, 83, 100
Locke, John, 11, 20, 25, 27, 29, 30, 38, 42, 68, 69, 80, 83, 95, 100, 107, 115, 129, 131, 145, 163, 171, 173, 177, 194, 198, 199, 205, 206, 222–4, 229, 230, 234–6, 245, 246–57, 262–8, 274–83, 291–2
against innate principles, 4, 262, 281
as a physician, 60
Essay, 4, 11, 25, 38, 42, 68, 115, 151, 171, 177, 193, 194, 198, 230, 261, 265, 266, 280–1, 283
logic, 25, 29, 151, 152, 178, 204, 205, 214, 218, 219, 226, 229, 230, 231, 243, 248, 277
Lohr, Charles, 22
Lossius, Johann Christian, 224, 225, 226, 230, 231
Lowe, E. J., 292
Luce, A. A., 282

Maclaurin, Colin, 173, 279
Magalotti, Lorrenzo, 4, 62
magic, natural, 21, 31, 32–5, 37, 39
Magirus, Johannes, 29
magnetism, 35, 39, 40, 43, 124, 170–1
Magnol, Pierre, 79
Malebranche, Nicolas, 64, 173, 236, 248, 254, 275–82
critic of experimental philosophy, 152
vision in God, 244
Malpighi, Marcello, 62, 102
Mandeville, Bernard, 246, 247
Mariotte, Edme, 6, 65
Marquis d'Argens. *See* de Boyer, Jean-Baptiste
Martin, Martin, 103–4

Masius, Didacus, 36
mathematics, 12, 13, 25, 30–1, 36, 55, 67, 98, 106, 114–15, 119, 122, 125, 128, 143, 145, 164, 172, 178–9, 198–9, 211, 213–19, 222, 230, 233, 243, 245–6, 253, 256, 280
  as a speculative science, 27, 33, 34, 36
matters of fact, 49–51, 107, 157, 166
Mauchart, Immanuel David, 224, 226
Maupertuis, Pierre-Louis, 173, 204, 217, 218, 221–2, 223, 295
  Principle of Least Action, 222
Maurolico, Francesco, 34
Maynwaring, Everard, 61
McCracken, Charles, 282
McMullin, Ernan, 296–7
mechanics, 21, 29, 32–9, 55, 58, 84, 106, 119, 121, 125, 130, 143, 163, 168, 174, 218–19, 222
medicine, 1, 13, 19, 21–4, 29, 42, 43, 55, 60–1, 84, 107, 162, 175, 195, 203, 209, 213, 218, 225, 286, 291
  Galenic, 45, 60, 69
  virtuoso-physicians, 60
Meier, Georg Friedrich, 243, 247, 250
Meiners, Christoph, 226, 229, 231, 260, 269, 275
Mendelssohn, Moses, 223, 225, 231
Merian, Johann Bernhard, 223
Merrett, Christopher, 60, 98–100
Mersenne, Marin, 63, 75, 83
Mesmin, Guy, 150
metaphysics, 20, 21, 22, 25, 27, 34, 35, 36, 63, 120, 152, 171, 178, 198, 212, 218, 219, 220, 223, 228, 231, 232, 239, 241, 245, 251, 252, 254, 255, 263, 273, 277, 295
meteorology, 104, 145, 147, 166–7, 212
microscopy, 54, 59, 287
Moletti, Giuseppe, 33, 35
Molyneux, Thomas, 42, 84, 104
Molyneux, William, 55–6, 70, 106
Monantheuil, Henri de, 35
Montagu, Sir Edward (Earl of Sandwich), 43
Montaigne, Michel de, 233, 246, 247, 249, 272, 277
Montanari, Geminiaro, 40, 62–3
Montesquieu, Charles Louis de Secondat, Baron de, 196, 233
Montmor academy, 41, 63
moon, motion of, 122
moral philosophy. *See* ethics
moral sciences, 20, 175, 177–8, 188, 207, 288, 291
Moray, Sir Robert, 53, 75, 94, 99, 113, 150, 297
More, Henry, 199, 276
Morison, Robert, 79
Moritz, Karl Philipp, 225, 226
Mothe le Vayer, François de, 276
motion, 48, 56, 58–9, 90, 105, 119, 122, 125, 128, 130, 138, 140, 193, 194
  natural *versus* violent, 33–5
Munro, Donald, 103
Musschenbroek, Pieter van, 148, 154, 173, 295

natural history, 12, 122, 156
  and chorography, 13, 87–8, 101, 103
  and experiment, 88
  and geography, 84–8, 142
  and the early Royal Society, 75–108
  Baconian natural history, 8, 12, 13, 63, 80, 147, 158, 189, 286
    compared with Classificatory natural history, 82–3
    decline of, 101–8, 141–7
  Classificatory natural history, 12, 13, 78–9, 82–3, 90, 103, 104, 106–7, 147, 155
  history of agriculture, 76, 98
  history of animal reproduction, 164, 165
  history of arts, 39, 76, 83, 86, 87, 90, 97, 98, 103, 162–3, 168, 190, 291
  history of celestial appearances, 75, 85, 165, 167
  history of cold, 13, 85, 91, 98, 99, 100, 101, 111
  history of colours, 90, 94, 99, 111, 112, 144
  history of concoctions, 96
  history of coughs, 42
  history of dense and rare, 83

natural history (cont.)
history of diseases, 61, 84, 85, 104, 145
history of fluidity and firmness, 13, 83
history of gems, 83
history of heat, 83, 161
history of human blood, 13, 83, 105
history of insects, 99, 106, 141, 160
history of life and death, 36, 81, 101, 161
history of man, 189, 190
history of materia medica, 95
history of mineral waters, 13, 83, 90–1, 101
history of plants, 84, 99, 108, 156, 167
history of refining, 99
history of rivers, 84, 86, 161–6
history of salt-petre, 100
history of the air, 13, 80, 83, 85, 101, 104–5, 145–7, 160–1, 167
history of the Earth, 79, 86, 102, 104, 105, 160–1, 167
history of the weather. *See* history of the air
history of tides, 85, 100, 167
history of trades, 96–101
history of winds, 36, 76, 81, 85, 101, 106, 154, 161–2, 167
history of wines, 99
Renaissance natural history, 12, 78–81
natural law, 177, 189–98, 240, 225, 262, 265, 268, 277
natural philosophy
as a speculative science, 20, 21, 24–38
natural religion, 67–9, 107, 118, 191–5, 235
natural theology, 178, 212, 262, 268
navigation, 34–5, 80, 143
Nedham, Marchamont, 60–1, 69
neo-Aristotelian theory of knowledge acquisition, 6, 7, 9, 22, 49, 158, 220
new philosophy, 47–8, 73, 127. *See* *novatores*
Newton, Isaac, 6, 14, 29, 67, 68, 70, 95, 102, 104, 107, 111–16, 121–47, 159, 170, 173, 189, 190, 197, 198, 209, 216, 219, 222, 229, 248, 273, 276, 277, 286, 288, 296, 298
'An Account of the Book Entitled Commericum Epistolicum', 139–40, 207, 297
'De natura acidorum', 132–3
'General Scholium', 133, 136, 138, 183, 194, 297
analysis, 11, 176
and experimental philosophy, 134–41
and natural history, 141–7
and queries, 112–14
and Varenius' *Geographia generalis*, 142–5
laws of nature, 122, 128, 130–1, 137, 192
on hypotheses, 11, 42, 115, 133, 136, 139, 183, 207, 297
optical lectures, 114, 143
Opticks, 131, 132, 138, 144, 145, 167, 176, 194, 205
Principia, 5, 70, 104, 107, 111, 114–16, 121, 123, 125–9, 132–39, 145, 148, 149, 183, 205, 206
prisms experiment, 95
rules of philosophising, 126, 129, 139
Trinity Notebooks, 112
Newtonian dynamics, 249
Nieuwentijt, Bernard, 149, 192
Het regt gebruik, 67
Nollet, Abbé Jean-Antoine, 154–6, 158, 159, 169, 175
Royal Professor of Experimental Natural Philosophy, 155
noologism, 234, 241–2, 247–8, 250, 262
North, Roger, 127, 144
novatores, 23, 48, 64

observation
standards of adequacy, 10
observation and experiment, 3–11, 24, 184–6, 204, 224
as a continuum, 71, 184
Observational philosophy, 227–33, 279

observationes, 24
oeconomy, 27, 29, 39, 178, 180
Ogilvie, Brian, 12, 78–80
Oldenburg, Henry, 39–40, 52, 56, 57, 76, 88–9, 92, 96, 99, 107, 112, 114, 141, 151, 296
ontology, 207, 213–16, 220–1, 229, 235
optics, 6, 29, 114–15, 119–20, 125, 143
Oswald, James, 228, 229, 248, 277
Oxford Philosophical Club, 43, 44, 50, 53, 96
Oxford Philosophical Society, 103, 106
Oxford physiologists, 45, 72, 73

Paduan Academy of Sciences, 219
Papin, Denis, 63
Pardies, Ignace-Gaston, 64
Parker, Samuel, 47, 68–70, 77, 209, 210, 276
Pascal, Blaise, 6, 44, 63, 95
  Puy du Dôme experiment, 44
Patrick, Simon, 48
Pecquet, Jean, 63, 95
Peiresc, Nicolas-Claude Fabri de, 40
Pepys, Samuel, 43
Perrault, Claude, 150
Perrin, Jean, 288
Pestre, Abbé Jean, 168
Pett, Sir Peter, 48, 53
Petty, Sir William, 43, 45, 70, 91, 92, 96, 98, 99–101
philology, 39, 218–19
philosophy of experiment, 8, 41, 288
  replication, 10, 288, 290, 291
  testimony, 10, 49–50
  typology of experiments, 92–96
    crucial experiments, 95, 108, 141, 285, 288
    exploratory experiments, 10, 95, 96, 288
    experiments solitary and experiments in consort, 94
    luciferous and fructiferous, 56, 90, 92–4, 97
physique, definition, 159
Piccolomini, Niccolò, 33
  Mechanical Problems, 33
Pico Della Mirandola, Giovanni, 32, 272
Pistorius, Hermann Andreas, 262, 263
Pitcairne, Archibald, 133
Platner, Ernst, 21, 230, 232
Plato, 197, 244, 246, 251, 255
  recollection, 4
Platonists, 128
Pliny the Elder, 12, 78, 80, 100
Plot, Robert, 98, 100
  Natural History of Oxford-Shire, 13, 87–8, 101, 103
  Natural History of Stafford-Shire, 143
Pluche, Abbé Noël-Antoine, 155
Plumian Chair in Astronomy and Experimental, 285. *See* Cotes, Roger
pneumatics, 63, 119–21, 124, 125, 170, 194
Poiret, Pierre, 276, 277
Poisson, Nicolas, 64
Poleni, Giovanni, 154
Polinière, Pierre, 153
political philosophy, 1, 25, 27, 29, 157, 178, 180, 182, 189, 207, 213, 235, 277, 280
Poliziano, Angelo, 29
Pomata, Gianna, 24, 293
Pomponazzi, Pietro, 22
Ponce de Santa Cruz, Antonio, 40
Pope, Alexander, 222
Powell, William, 121
Power, Henry, 58
  Experimental Philosophy, 23, 53, 64, 206
prepossession, 11, 19, 117
pressure of the air, 44, 45
Price, Richard, 277
Priestley, Joseph, 248, 277, 279, 290
principles, 6, 9, 10, 20, 22, 48, 51
Pseudo-Albertus Magnus, 32
Pufendorf, Samuel, 199, 275, 277
Pythagoreans, 128, 277

Raleigh, Sir Walter, 39
Ramus, Petrus, 78
rationalism, 3, 233

rationalism/empiricism distinction, 14, 203, 233
classificatory bias, 236
epistemological bias, 235
Kant's contribution to the standard narrative, 237
Kantian bias, 235
Rawley, William, 105
Ray, John, 79, 108
Réaumur, René-Antoine, 155
Redi, Francesco, 62
Regís, Pierre-Sylvain, 64
Reid, Thomas, 180–3, 189, 196, 197, 204, 223, 228, 229, 248, 277
on hypotheses, 183
on laws of nature, 197
Reinhold, Karl Leonhard, 14, 230, 232, 254, 242, 257, 260, 262, 264–9, 274, 281, 282
on Leibniz's rationalism, 264–7
on Locke's empiricism, 264–7
on observational philosophy, 232
Renaissance natural history. *See* natural history
Rey, Anne-Lise, 295
Riccioli, Giovani Battista, 277
Roberval, Giles Personne de, 63, 134
Robinson, Thomas, 102
Rochefoucauld, François de La, 275
Rochon, Antoine, 64, 65
Rohault, Jacques, 64, 70, 72
Traité de physique, 65, 66, 92, 133
Roux, Sophie, 64, 65, 66
Royal Society, 55, 60, 150–1, 157, 173, 205, 210, 273
early, 29, 30, 38, 41, 43, 53–6, 60–4, 73, 75–7, 89, 221, 229, 285, 288
and natural history, 85, 96–101, 105–6, 112, 141–7
Royal Society Boyle Papers, 88
Russell, Bertrand, 14

Saint-Joseph, Pierre de, 29
Sánchez, Tomás, 36
Sancto Paolo, Eustachius, 29
Sarotti Academy, Venice, 63
Sarotti, Giovanni Ambrosio, 63
scepticism, 245–6, 249, 254–7, 259, 264, 266, 267, 269, 272, 275, 280, 290
Schaumann, Johann Christian Gottlieb, 231
Scheibler, Christoph, 29, 277
Schelling, Friedrich Wilhelm Joseph, 269
Schiller, Friedrich, 226, 227
Schliesser, Eric, 292, 295–8
Schmaltz, Tad, 152
Schmid, Carl Christian Erhard, 231, 233, 261, 262, 263, 267
Schmitt, Charles, 72
Scholasticism
see Aristotelianism, 69
science of man, 20, 178, 185–6
scientific syllogisms, 48, 49
Scilla, Agostino, 62
Scioppius, Caspar, 277
Scottish moral philosophy
and laws of nature, 191–7
and natural history, 189–91
Scotus, Duns, 36
Search, Edward, 229
Selle, Christian Gottlieb, 231, 232, 252, 261–3
Senebier, Jean, 185
Seneca, 30
Sennert, Daniel, 26–29, 33, 36
divisions of knowledge, 27
Sergeant, John, 5, 19
Sesto, Russiliano, 32
Shaftesbury, Third Earl of, 275
Shakespeare, William, 226
Shapiro, Alan, 137, 138
Sharrock, Robert, 97, 98
Shaw, Peter, 141, 142, 162
Simpson, William, 47, 69
Sloan, Phillip, 160
Sloane, Sir Hans, 147
Smith, Adam, 25, 182
Smith, Pamela, 293
Smith, Robert, 123
Socrates, 20, 197, 243
Sorbière, Samuel, 99
soul, study of, 22, 63, 171, 178, 223–7
South, Robert, 38

speculative philosophy, 4, 6, 7, 19, 69, 122, 285, 289
'speculative philosophy'
disciplinary sense, 12, 204
methodological sense, 12
and Kant, 232, 233
and the Berlin Academy, 218
as a contrast class, 286, 294, 295
as a methodology, 19
as a strawman, 295
critique of by moral philosophers, 181
speculative versus practical sciences, 178
Spink, Aaron, 70
Spinoza, Baruch, 199, 234, 236, 248, 254, 255, 273, 275, 276, 277, 278–81, 291
Sprat, Thomas, 46, 54, 72, 73, 92–3, 100, 150, 209
History of the Royal-Society, 56, 68, 94, 112
Stahl, Georg Ernst, 159
Steele, Richard, 141
Stillingfleet, Edward, 55, 192
Stoicism, 249, 277
Stoic division of philosophy, 25
Stubbe, Henry, 5, 73, 100
Sturm, Christoph, 120, 205
Suárez, Francisco, 36
Sulzer, Johann Georg, 223, 224, 225
Swammerdam, Jan, 80
Sydenham, Thomas, 60, 84, 210

Tartaglia, Niccolò, 34
Taylor, John, 80
Telesio, Bernardino, 23, 69
ten Kate, Lambert, 67, 149, 192
Tennemann, Wilhelm Gottlieb, 14, 203, 235, 242, 257, 258, 259, 268–84
and the classificatory bias, 248
on Locke's empiricism, 281
periodisation of early modern philosophy, 272
testimony, 10, 49
Tetens, Johann Nicolaus, 5, 20, 204, 223, 224, 225, 253, 333
on observational and speculative philosophy, 227–30
Philosophical Essays, 223, 227, 229
Thales, 20
theology, 177, 207, 263, 265, 282
Theophrastus, 78
theory ladenness of observation, 11
Thomas, St (Aquinas), 26, 36, 37
divisions of knowledge, 26
Thomasius, Christian, 275, 276, 277
tides, problem of. *See* natural history
Tiedemann, Dieterich, 256, 259, 263, 270, 275
Tillotson, John, 192
Timpler, Clemens, 29
Tittel, Gottlob August, 263
Toland, John, 207, 297
Toletus, Franciscus, 26, 28, 29, 33, 36, 37
divisions of knowledge, 27
Tomeo, Leonico, 33
Torricelli, Evangelista, 41, 45, 273, 286
Torricellian apparatus, 11, 44, 65, 66, 95
Tournefort, Joseph Pitton de, 79
Towers, John, 194
Tschirnhaus, Ehrenfried Walter von, 276, 278, 279
Tunstall, James, 176
Turnbull, George, 14, 20, 37, 176, 189, 196, 197
innate idea of God, 4
on hypotheses, 183–4
on laws of nature, 196
Tyrrell, James, 199
Tyson, Edward, 80

vacuum, 11, 44, 65, 131
Valmont, Jacques-Christophe de Bomare, 156
Valois, Louis Le, 64
van Helmont, Joan Baptiste, 69, 277
Varenius, Bernard, 106, 142, 143, 145
Geographia generalis, 84–7
Vaughan, Thomas, 80
Vesalius, Andreas, 23
Viviani, Vincenzo, 44
Vives, Juan Luis, 34
Voltaire, 148, 157, 158, 167–8, 169, 174, 175, 206, 221

Voltaire (cont.)
and Bacon, 153–4, 171
and Newtonianism, 153
critic of Descartes, 157, 173
vortex theory. *See* Cartesianism

Wallis, John, 46, 55, 100, 106, 194, 195
Walsh, Kirsten, 288
Ward, Seth, 50, 96
Warntz, William, 143, 145
Watts, Gilbert, 2
Watts, Isaac, 177
Watts, Thomas, 116
Watts, William, 2
Waxman, Wayne, 252
Webster, Charles, 96
Webster, John, 83, 96
Whewell, William, 274
Whichcote, Benjamin, 199
Whiston, William, 48, 120, 123, 125, 149, 195
A New Theory of the Earth, 104
Astronomical Principles of Religion, 69, 192
Whiteside, John, 120, 124
Wilkins, John, 33, 43, 46, 72, 98, 192, 193
Principles and Duties of Natural Religion, 192
Will, Georg Andreas, 232
Willughby, Francis, 107
Wolff, Christian, 5, 132, 166, 176, 203, 222, 230, 232, 233, 247, 249, 250, 275, 277, 279, 280, 286
and experimental philosophy, 204–17
and principle of sufficient reason, 215–16
and the a priori, 211–17
on Bacon, 206
on Boyle, 206
on definitions, 215, 216
on hypotheses, 206–12
on Newton, 206, 209
on psychology, 212
on self-consciousness, 215
psychology of, 223
Woodward, John, 98, 102, 127–8
Natural History of the Earth, 79, 84, 102, 104, 160, 161
Worsley, Benjamin, 86–7
Worster, Benjamin, 116
Wotton, William, 102
Wren, Matthew, 46
Wren, Sir Christopher, 43, 53, 54, 58, 194, 195, 211

x-phi, 3, 184, 198, 298

Zallinger, Jacob, 42
Zaluziansky, Adam, 78